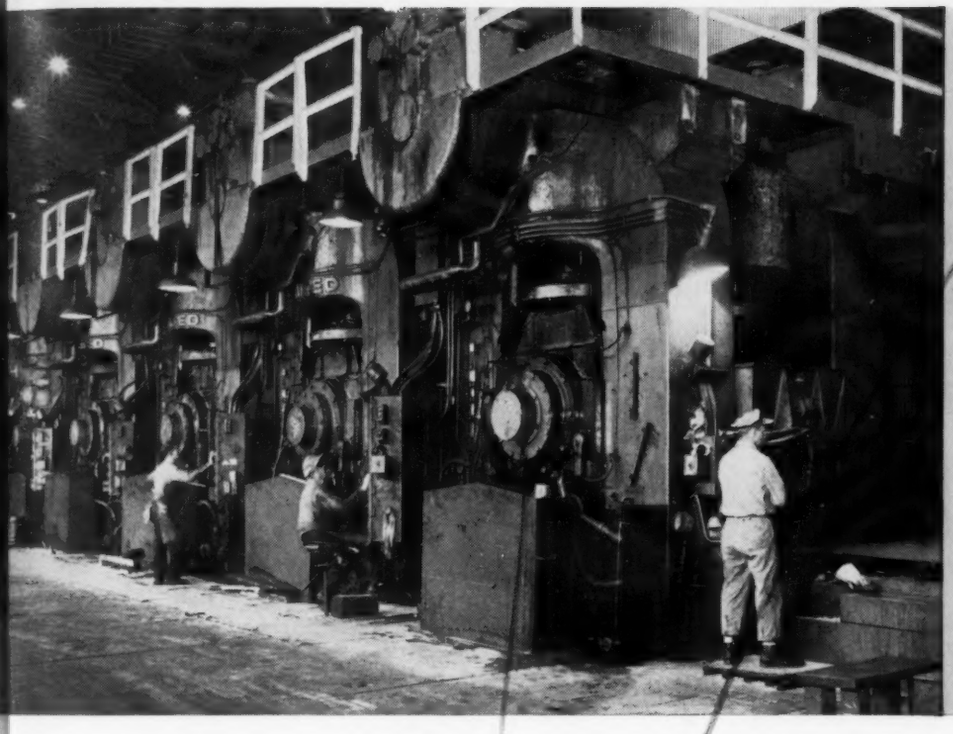
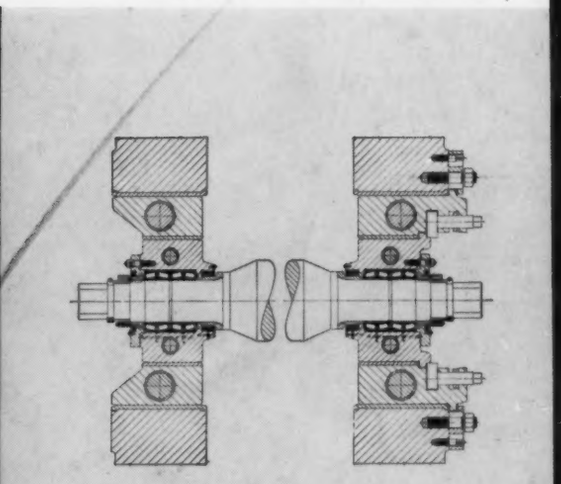
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

NOVEMBER, 1958





UNITED ENGINEERING mounts the work roll necks on the 4-high cold rolling mill on Timken tapered roller bearings to give lower cost per ton of steel rolled.

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DETROIT

How Weirton cold rolls steel up to 5,000 F.P.M.

COLD rolling steel up to 5,000 F.P.M. calls for bearings with real guts. That's why United Engineering specified Timken® tapered roller bearings on the work roll necks of this 4-high tandem cold mill built for Weirton Steel Company, Division of National Steel Corporation. And to maintain gage and quality at these high speeds, they specified Timken bearings on the mill gear drives and pinion stands, tension reel, payoff reel screwdown drive, the coil transfer car, coil rotating rig and for the tilting gear drive for the coil unloader.

Timken tapered roller bearings have the high radial and thrust capacity you need for modern steel mills. They're tapered to take any combination of radial and thrust loads. And they're case-carburized to produce hard, wear-resistant surfaces over tough, shock-resistant cores. Both are reasons why Timken bearings have records in steel mills the world over.

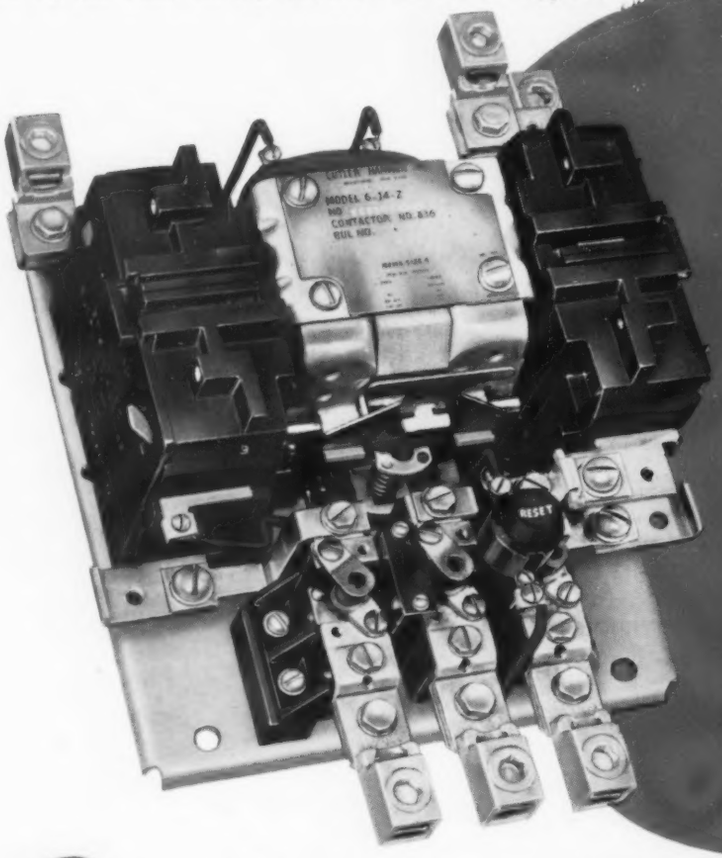
Because Timken bearings practically eliminate friction, cut starting resistance, they cut scrap losses to a bare minimum. Grease lubricated, they cut maintenance costs to the bone. It all adds up to lower bearing cost per ton of steel rolled . . . why Timken tapered roller bearings are on the roll necks of 1,008 mills.

Specify Timken tapered roller bearings for the next rolling mill you buy or build. They make good machines better, help turn out a better product for less money. And with Timken bearings you get the best engineering service there is. That's Better-ness. And Timken bearings are the symbol of Better-ness. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

BETTER-ness rolls on **TIMKEN®** tapered roller bearings

50 Hp 220 Volts, 100 Hp 440/550 Volts Max. Polyphase



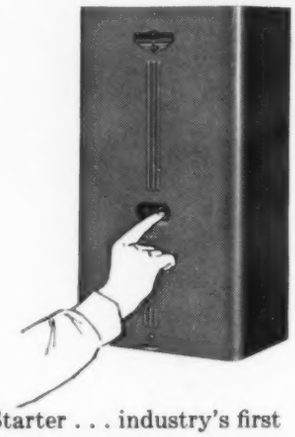
New SIZE 4 STARTER

. . . another Cutler-Hammer Three-Star achievement

New *compact design saves valuable panel area*

New *parallel contact design provides increased electrical life at full capacity*

New *low mass movable members insure superior mechanical life*



This is the new Cutler-Hammer NEMA Size 4 Starter . . . industry's first large horsepower starter offering all the desired features of the famous Cutler-Hammer Three-Star Motor Control line. Smaller, more compact, this new starter simplifies control panel design and saves valuable panel area. Tests of the new parallel contact structure show vastly improved electrical life even when operated at full capacity. Further, this new design reduces the size and weight of the movable members resulting in less impact wear and unsurpassed mechanical life. We've tested it against all others, why don't you? The new Cutler-Hammer Size 4 Starter ☆ installs easier, ☆ works better, ☆ and lasts far longer. Get all the facts today. Write for the new descriptive bulletin EN 125-V-232.Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Look for these outstanding features . . . you'll find them only in Cutler-Hammer Three-Star Motor Control

- U-shaped cover easily removable for unobstructed inspection and accessibility
- Straight through wiring . . . line terminals at the top, load terminals at the bottom
- New pressure type terminals cut wiring time and effort
- Adjustable overload relays can be set to trip within 3% of full load motor current
- Precision cast overload sensing coils can't lose their accuracy
- Widely desired three-phase, three-coil overload protection is a standard optional feature . . . no special attachments or enclosures
- Indestructible molded magnet coil . . . color coded for positive voltage and frequency identification
- Easily installed convertible electrical interlocks require no special adapters . . . provide up to four extra control circuits
- Available as non-reversing, reversing, and multi-speed contactors and starters in the open type, NEMA 1, and all special purpose enclosures.

CUTLER-HAMMER CONTROL C-H

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**

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from Blaw-Knox . . .

BeeKay refractory products include silica and high alumina brick, super duty, first quality and intermediate quality fire brick, plastic fire brick, Missouri quality products, cements and mortars, and castable products.

the BeeKay refractory line

The list of Blaw-Knox products and services for the metals industry has grown steadily since the company's founding. Now Blaw-Knox adds the complete line of BeeKay refractories to better serve this industry.

The BeeKay product-service combination adds up to a program of supply designed to cut costs through the use of refractory materials specifically matched to job requirements.

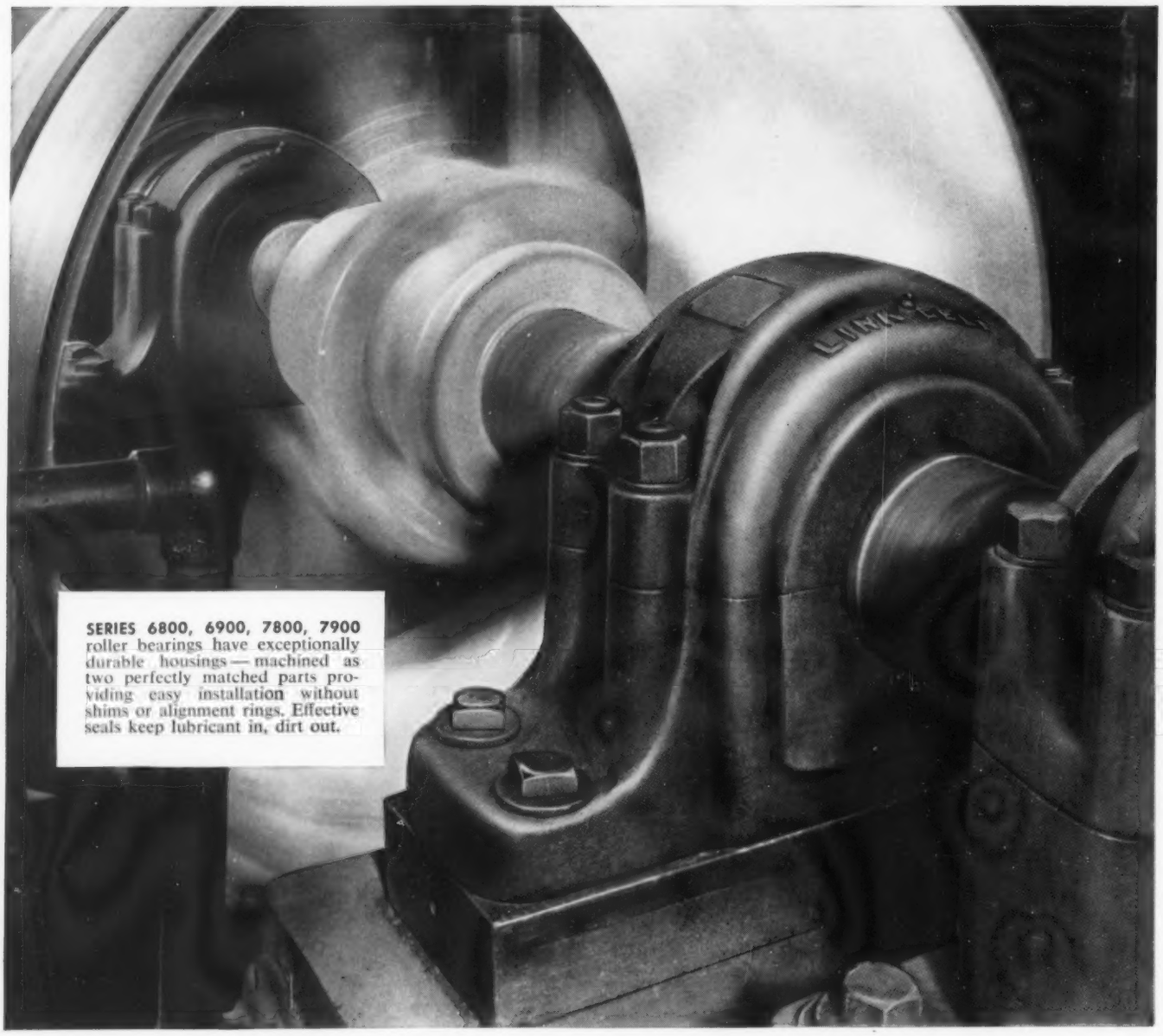
BeeKay materials are top quality. Clay earths as well as all additive materials are processed by the most modern methods and machinery. Constant quality control is exercised both in process and in a fully equipped laboratory.

Finally BeeKay service. Since Blaw-Knox is a constant user of refractories in its own furnaces, the company has a customer's understanding of transportation, delivery and inventory problems. Your BeeKay refractory man will be glad to assist you in the selection of the proper refractory for your operation as well as providing the service to assure efficient, economical inventories. For complete details, write for a copy of Bulletin 2564.

BLAW-KNOX

BLAW-KNOX COMPANY
300 Sixth Avenue
Pittsburgh 22, Pennsylvania

NO PINCH, NO BIND-- ALWAYS-ALIGNED



SERIES 6800, 6900, 7800, 7900 roller bearings have exceptionally durable housings — machined as two perfectly matched parts providing easy installation without shims or alignment rings. Effective seals keep lubricant in, dirt out.

These husky bearings in husky housings adjust *instantly* to shaft misalignment

Shaft deflection often means quick failure for ordinary bearings . . . but not for these rugged Link-Belt *self-aligning* bearings. Adjusting immediately in any direction, they easily compensate for misalignment . . . avoid damaging "pinch" and bind.

You can get full information on Link-Belt's complete bearing line from any one of 40 Link-Belt offices. Or contact your authorized stock-carrying distributor.

Spherical bearings are free to align in any direction, assuring full load capacity regardless of shaft deflection.

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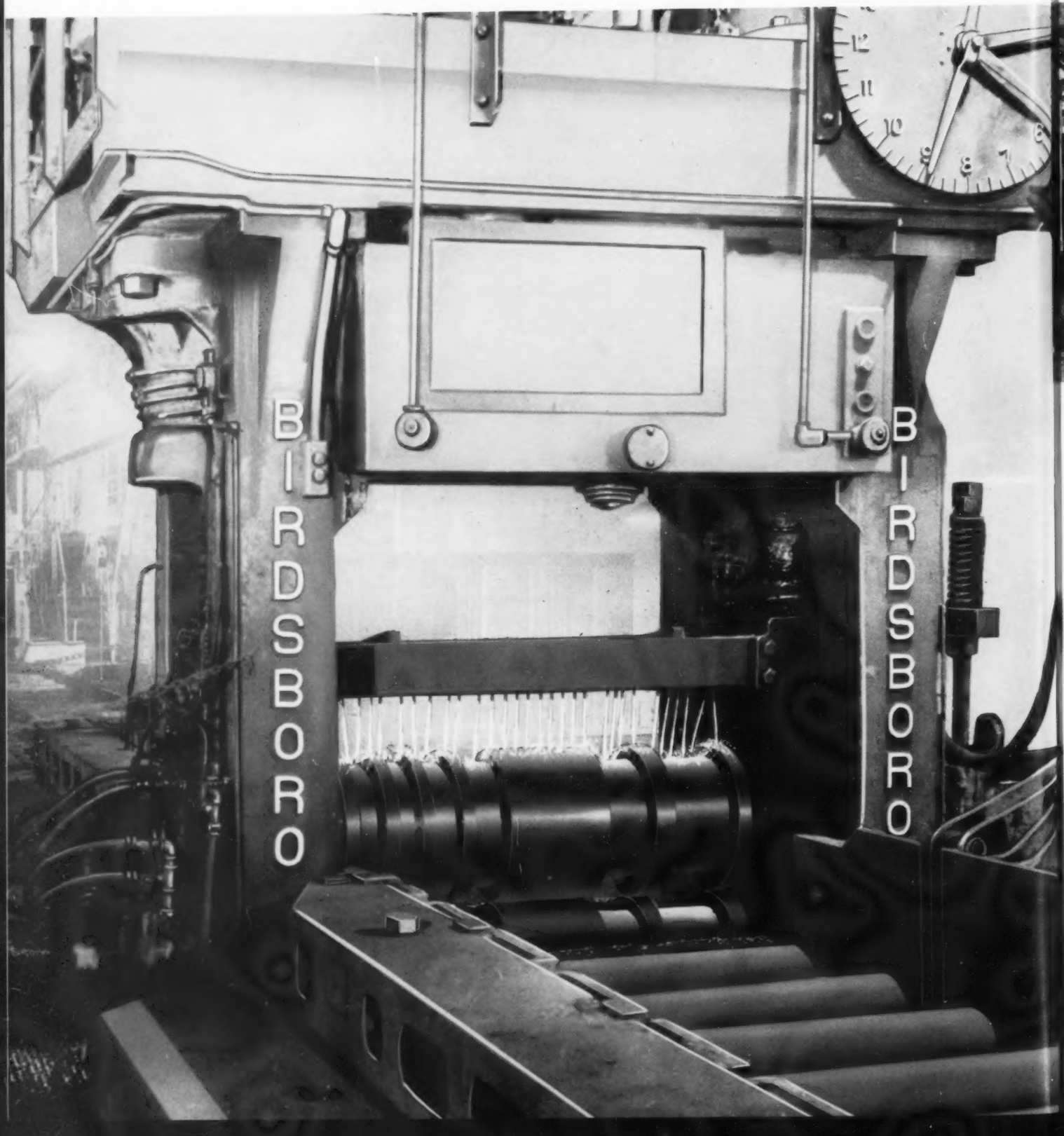
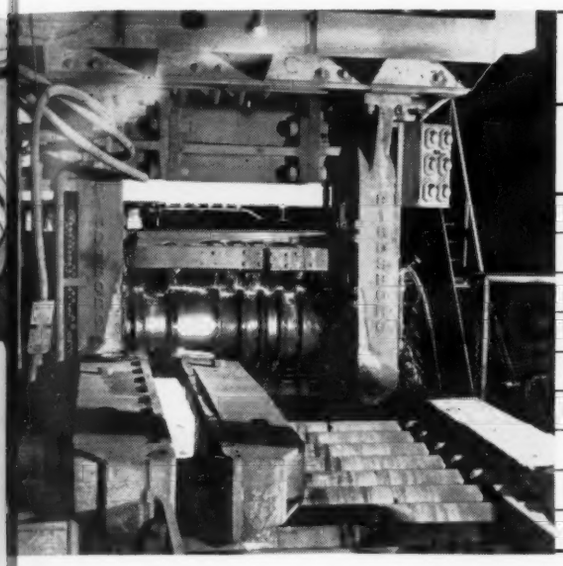
BIRDSBORO

give users added flexibility,



2-High Reversing Mills...
new profit potential



Check These Applications of BIRDSBORO 2-High Reversing Mills in Operation:

Size of mills	Primary blooming & slabbing	Secondary billet & slabbing	Structural roughing	Strip & skelp roughing	Merchant bar & rod roughing	Tube & extrusion Rough finishing
36"	✓	✓				
35"	✓					
34"		✓				✓
32"	✓	✓	✓			
28"					✓	
26'	✓	✓		✓	✓	✓
22"	✓					✓
20"	✓			✓	✓	
18"	✓					

● Ranging in size from 36" down to 18", these mills are improving production records in plants in the United States, Canada and South America. Almost every important name in the steel industry is listed among the users of Birdsboro mills.

Among the many features is VARIABLE SPEED, an inherent characteristic of the 2-high reversing mill. Here is why it is important:

1. spread may be controlled by varying the rolling speed.
2. difficulty in entering hard or slippery grades can be overcome by entering at slow speeds.
3. production can be maximized by taking initial passes at low speed, where entry is difficult, and speeding up on the final long passes.
4. slow speeds can be used to avoid rupturing the surface of tender grade ingots, until sufficient work has been done to permit faster rolling.

This comment about a Birdsboro 2-high reversing mill appeared in a national engineering magazine:

". . . I find it very difficult when talking about this two-high mill to keep my enthusiasm under control. I honestly think this is one of the finest pieces of equipment that it has ever been my pleasure to work with. It is so completely flexible."—Superintendent of one of the leading specialty steel mills in the Eastern U.S.

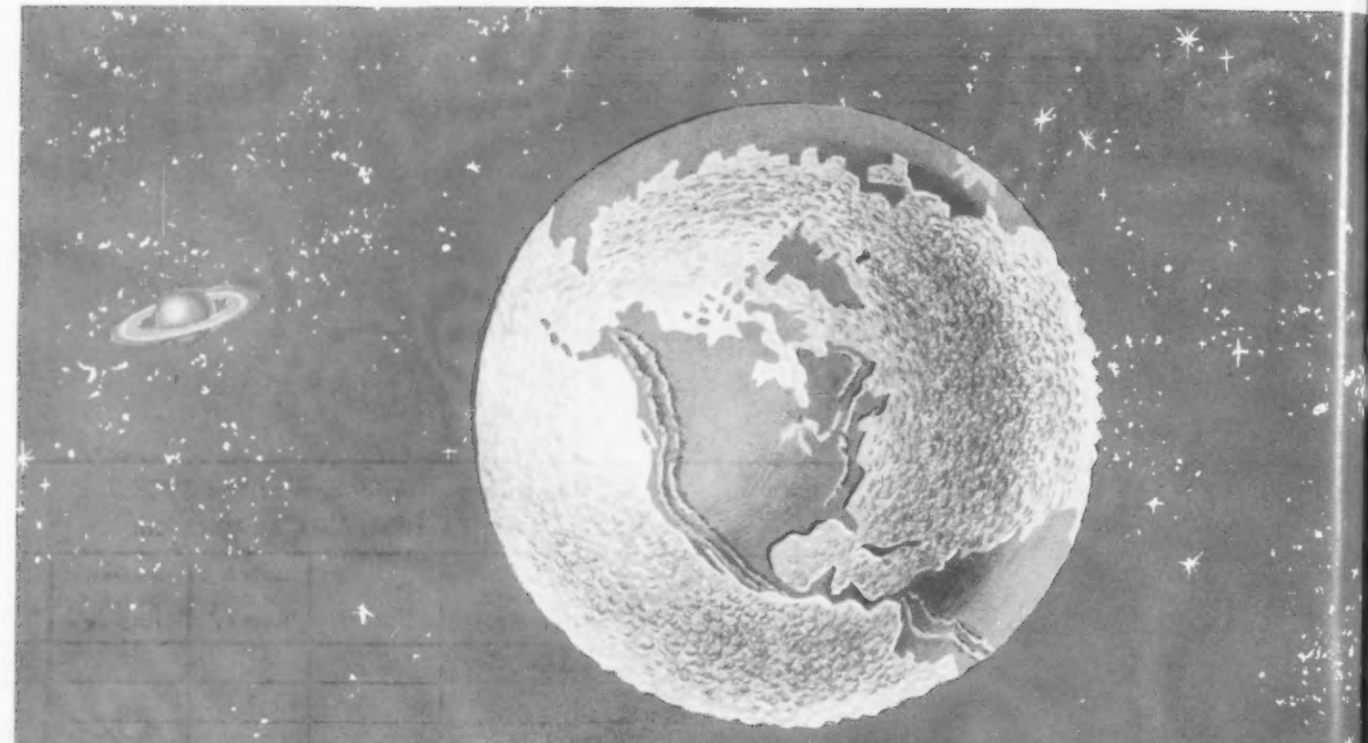
Your nearest Birdsboro mill machinery representative can give you a lot more of the details on our handling of special engineering problems in rolling steels. *Main Office, Engineering Department and Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.

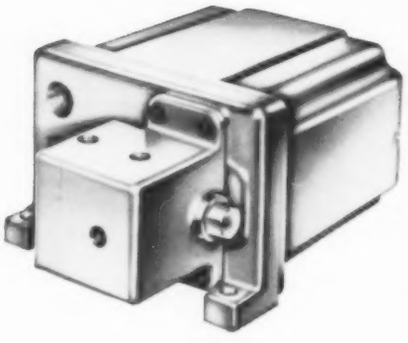
MM 70-58

BIRDSBORO

STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • Weldments "CAST-WELD" Design
ROLLS: Steel, Alloy Iron, Alloy Steel





Above, left—The GPE Controls Electric Flow Transmitter, a completely new idea in flow signal transmission. Completely transistorized, without complex mechanics, it transmits a high-level signal proportional either to flow or to differential pressure. Precise measurement and signal transmission are first in importance in good control.

Above—The Libratrol-500 Process Control System, made by Librascope and available to industry through GPE Controls, Inc., is developed around this highly reliable, rapid-response digital computer. It provides for a full range of process control—from accurate processing of data to provide understandable information to a human operator, to complete automatic control of an entire process or group of interrelated processes.

Left—One of many GPE Controls Electrohydraulic Valve Actuators that combine the speed and positive action of hydraulic valve operation with the flexibility of electrical control and signal transmission.

In the world of

IRON and STEEL CONTROLS...

tomorrow is already here!

What do you expect of tomorrow's automatic control systems for iron and steel production? If you are looking forward to the advantages of computerized control systems . . . greater reliability in signal transmission . . . further localization of the control function, with centralized supervision . . . better response of final control elements . . . then for you tomorrow is already here.

GPE CONTROLS, Inc. brings to the steel industry computer controls, components, and greater understanding of system dynamics – offered by several subsidiary companies of General Precision Equipment Corporation: *Librascope* for digital data-logging and closed-loop computer systems and components; *Kearfott* for high-performance hydraulic components and controls; *Link Aviation* for analog computer controls, product service, and manufacturing capabilities; *Askania* for more than 25 years of dealing with the automatic control problems of steel production.

GPE CONTROLS, Inc. welds together all these industrial control capabilities and makes them directly – and immediately – available to you.

Why not see what the engineers of GPE Controls can do for you? You'll be seeing this nameplate on the most exacting control-computer installations – soon and often.

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GENERAL PRECISION EQUIPMENT CORPORATION GPE

. . . serving industry through coordinated precision technology

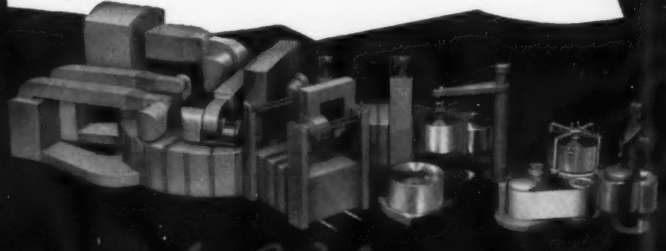
To anneal it better... faster...

.....open it up....

...heat every wrap with exacting precision...

...recoil for processing

Lee Wilson's revolutionary new coil opening system exposes as much as 400 times more coil area to furnace heat. This obviously means faster heating with substantially better control... a better annealed product, and production rates that reduce process inventory at annealing stations by 80 percent. Be sure you have all the facts on the amazing new Opened Coil Annealer before you purchase additional annealing furnace equipment.



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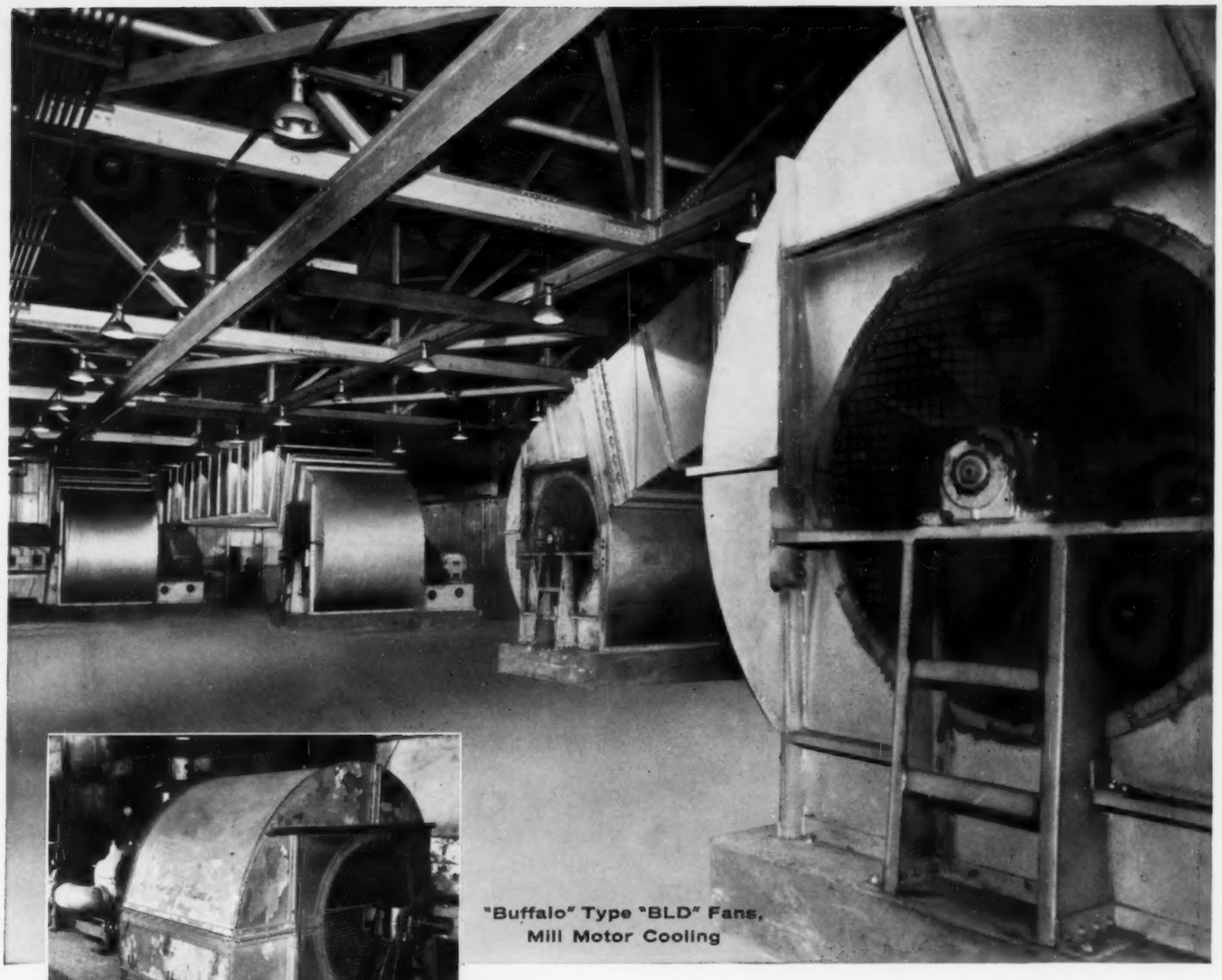
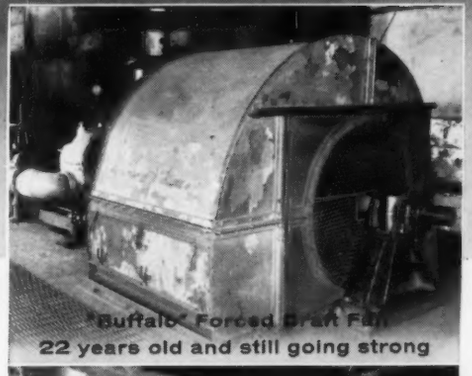
MAKE THE BEST METALS BETTER

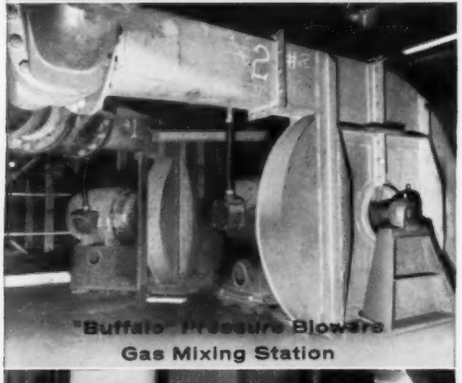
★ ORIGINATORS AND LEADING PRODUCERS OF OPENED COIL AND SINGLE STACK FURNACES



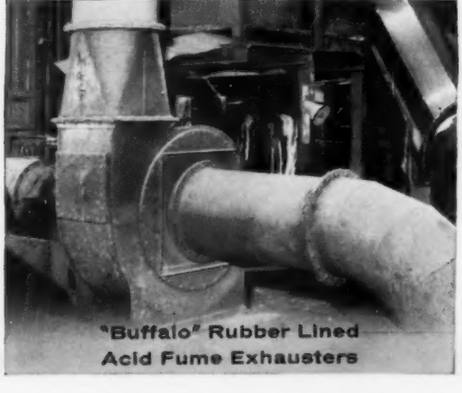
"Buffalo" Type "BLD" Fans,
Mill Motor Cooling



"Buffalo" Forced Draft Fan
22 years old and still going strong



"Buffalo" Pressure Blowers
Gas Mixing Station



"Buffalo" Rubber Lined
Acid Fume Exhausters

FROM MILL MOTOR COOLING TO ACID FUME EXHAUST

Weirton Steel Company Uses "Buffalo" Fans

By their very nature, fans and other air handling units manufactured by the Buffalo Forge Company are ideally suited to steel mill work. The Weirton Steel Company, division of National Steel Corporation, Weirton, West Virginia, discovered this over 40 years ago and have been using "Buffalo" units ever since. Today, they have "Buffalo" fans for open hearth combustion air, mill motor cooling, pressure blowers for gas mixing, rubber lined fans for acid fume exhaust, boiler forced draft fans, central heating system fans and over 200 unit heaters.

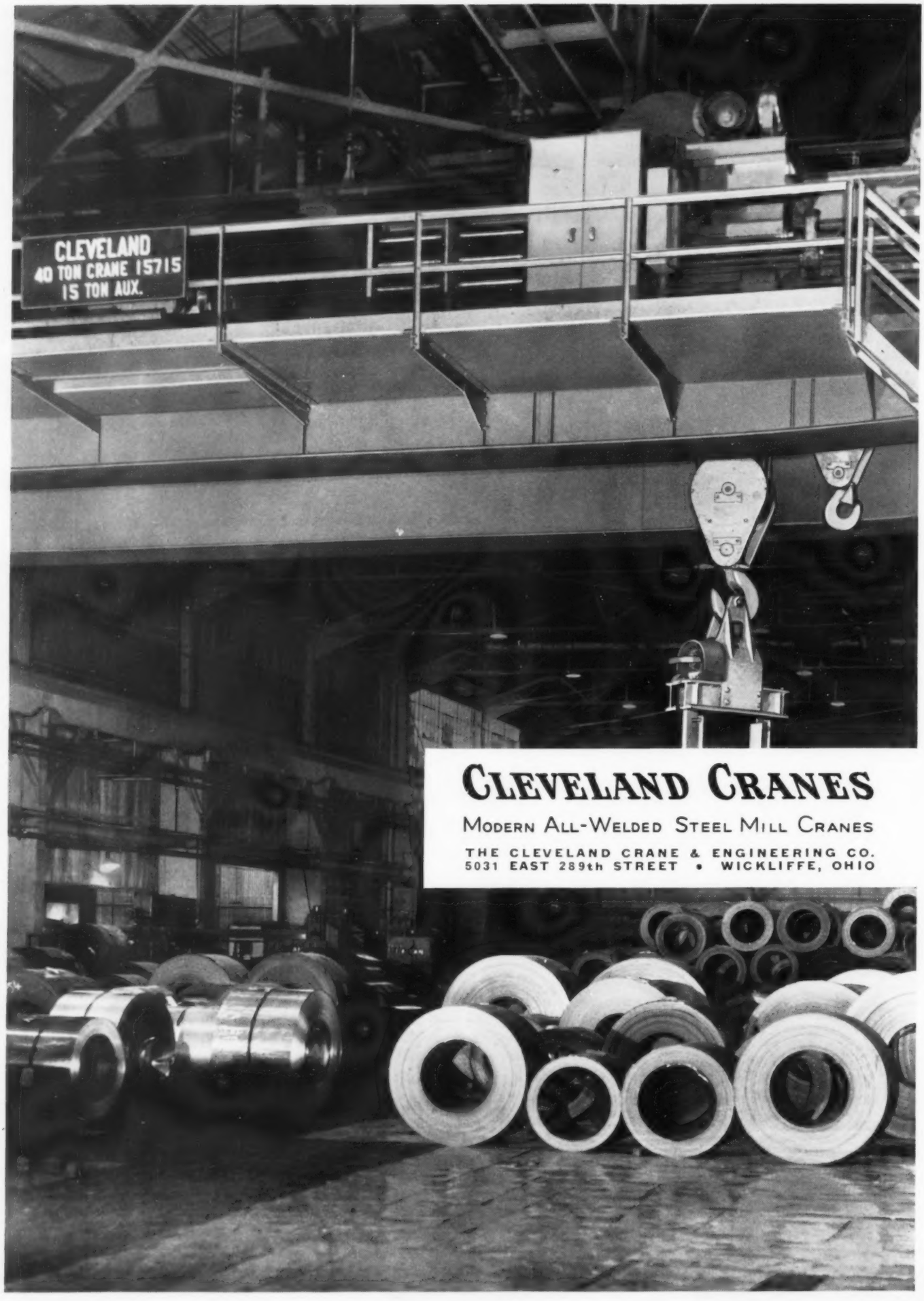
You, too, will be more than satisfied with "Buffalo" air handling units. There is probably a type and size to fit every application in your plant.

The next time you want to handle air, call your nearest "Buffalo" Engineering Representative. Or write for the information you need.

BUFFALO FORGE COMPANY
Buffalo, N. Y.

Buffalo Pumps Division • Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT
EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

THE CLEVELAND CRANE & ENGINEERING CO.
5031 EAST 289th STREET • WICKLIFFE, OHIO

Crops *and* Shorts

△ A. S. Glossbrenner, president of Youngstown Sheet and Tube Co., told the Cleveland regional meeting of the American Iron and Steel Institute that it is essential that the industry's workers become well acquainted with the policies, ambitions and over-all goals of their companies and of the whole industry. He believes that too much leadership in the field of industrial relations has been lost by default.

△ We think it's only an exaggerated rumor, but we've heard that a future demand in labor contracts will call for a guaranteed amount of money to be returned to the worker from his take-home pay after he takes it home.

△ William G. Caples, vice president of Inland Steel Co., does not believe that present anti-trust laws should be used to regulate unions and curb union corruption. He thinks there should be laws to block union pressure attempts to restrict trade and influence prices and areas of sales. Also, union affairs and actions that affect the interests of workers should be under constant scrutiny. He suggests rigid enforcement of laws requiring public disclosure of union finances and of health, welfare and pension plans. A suggested means might be state chartering of unions, requiring constitutions and by-laws which guard membership rights, secret elections, regular meetings, etc.

△ The only place the old economic law of supply and demand still holds good is in our tax system. We supply what the collectors demand.

△ Panama's first steel mill, the Panama Steel Co., recently started operations. Built at a cost of $600,000, the plant will produce reinforcing bars and small steel shapes from local scrap.

△ Thomas F. Patton, president of Republic Steel Corp., says that labor monopoly and special legal privileges have caused our inflation problem, and concerted action by business, greater understanding by the public and firm action by government are needed to solve it. He warns that continuance of the present cost trend will lead to inflation that will make it practically impossible for industry to expand.

△ The Wall Street Journal observes:

This question has my mind distressed
Through all my daily tussles:
Why can't the young-in-heart be blessed
With matching bones and muscles?

△ Clifford F. Hood, president of United States Steel Corp., wants the government to undertake a "cost analysis" of its fiscal expenditures on the basis followed by a "profit-motivated business."

"Even the strongest and wealthiest nation in the world cannot long endure a situation where the government is subtracting the capital resources of its people and its industries just about as fast as enterprise is adding them," he said. He stressed that for every dollar profit made by corporations that is used in multiplying the growth factors in our economy, the federal government collects more than a dollar in corporate income tax.

△ The hula hoop craze seems to have passed its peak, but for those who wish to carry it on in luxury, there's a neat little mink-covered hoop available at $100 a copy. And a dress manufacturer in Buffalo reports that the women workers have given up their coffee breaks and spin hoops instead. Their production has gone up 20 per cent.

△ The full impact of the recent wage increase in the steel industry is now being felt, with the average hourly wage cost above $3.27, not including an average of over 33 cents per hour for pensions, social security and insurance.

△ When you walk through an exhibit of modern sculpture, it's apparent that a sculptor today is a person who can take a rough block of stone or wood, work on it for months, and make it look like a rough block of stone or wood.

△ Supported by a $95,000 grant from the Fund for the Advancement of Education, a nation-wide study will be made of co-operative education. About 60 colleges and universities now have co-operative programs, wherein students alternate periods of work in school and in industry as a regular part of their degree programs. The plan, inaugurated in 1906 at University of Cincinnati, has many proponents among educators and industrialists.

△ From Banking: Salary is an amount of money that no matter how large it is some people spend more than.

△ One of our contemporaries says you've reached middle age when all you exercise is caution.

△ Americans have long been known for their proclivity to form societies and attend conventions. Now comes a brand new group: the American Association of Retired Persons. Headquartered in Ojai, Calif., it is a "national nonprofit educational, philanthropic, scientific organization serving retired persons of the nation." Incorporated under the laws of the District of Columbia, its activities include research, counseling, correspondence, Modern Maturity (a magazine, Vol. 1, No. 1, October-November, 1958), AARP insurance plan and travel service. Annual dues are $2.

The new group is apparently a broadening of the idea behind the National Retired Teachers Association founded in 1947 and now said to have 100,000 members.

△ The William Feather Magazine observes that the chief trouble with the contemporary generation is that it has not read the minutes of the last meeting.

BRISTOL'S INSTRUMENTATION

NEWS AND INFORMATION ABOUT AUTOMATIC CONTROLLING AND

THEY CALL IT "the instrument man's instrument"

That's because more and more instrument men—engineers, scientists and research workers—are turning to Bristol Electronic Dynamaster* potentiometer and bridge instruments to fill exacting requirements. These men *demand* the utmost in instrument accuracy, precision and dependability; they *need* an instrument that's outstandingly versatile and adaptable in application. They get these qualities and more in Bristol Dynamaster instruments. Take these Dynamaster features, for example:

1. Continuous standardization—accurately, automatically, and continuously standardizes potentiometer against standard cell with no interruption to control. Eliminates dry cells and usual standardizing mechanism.
2. High accuracy . . . fast, continuous electronic measurement.
3. Simple in design . . . few moving parts.
4. Easy to use and service . . . little or no maintenance required.
5. Flexible in application.
6. Rugged construction . . . ideal for industrial plants, pilot plants, and for research and laboratory use . . . unaffected by vibration.

Models for every purpose. Dynamaster electronic instruments are available as single-pen, two-pen, and multiple-record (up to 24 points) strip chart instruments. Round chart instruments are also available with one and two pens.

(And remember the 3-inch-strip-chart miniature Dynamaster described below.)

Electric and pneumatic controllers. Both strip- and round-chart instruments come with a wide variety of controllers. The following are available in a great many forms:

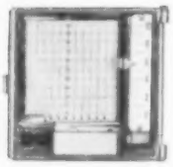
Electric Control—On-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—On-off, proportional, proportional with reset, and proportional with reset and derivative.

*T.M. Reg. U.S. Pat. Off.

Bristol Dynamaster* recorder with strip chart.

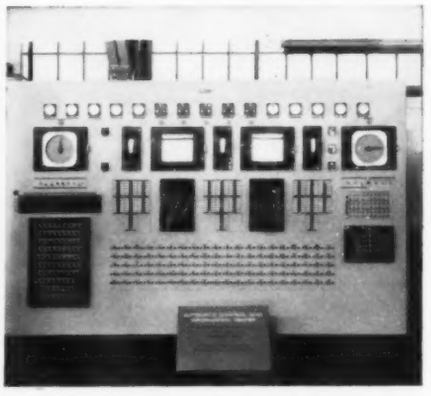
This new electric miniature takes on big jobs



New Bristol Series 663 miniature Dynamaster instruments plug into panel space of only 5"x5⅛". But they work on the same motor-driven self-balancing principle as full-sized Bristol Dynamaster instruments. This proved motor-driven null-balance principle not only gives high accuracy (½% of scale) but insures plenty of torque for operating alarm contacts, retransmitting slide-wires, and electric control contacts—features that ordinary galvanometer-type instruments don't have.

Plugs in, too. What's more, the Series 663 Dynamaster has a true plug-in chassis. You can change from an indicator to a recorder, or vice versa, in 10 seconds, or plug in spare instruments with minimum interruption to recording or control.

Ask us for complete data on Series 663 Dynamaster recorders and indicators today. As the only manufacturer making a complete line of *both* miniature and full-size instruments we're in unique position to give your instrument needs unbiased consideration.



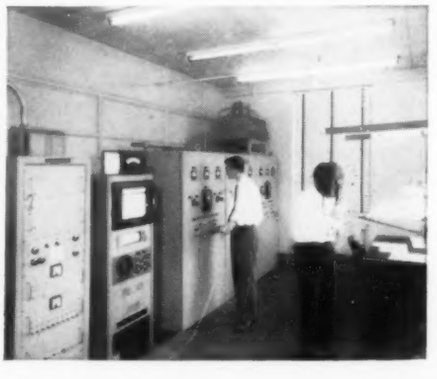
Keeping tabs on atoms

This automatic control and information center, designed and built by Panellit, Inc., for Knolls Atomic Power Laboratory features four Bristol Dynamaster instruments (in second row from top). Dynamaster recorders and controllers are finding wide application in atomic energy, as in other industries, where precision, accuracy and reliability are prime requirements.

Break "thermal barrier"

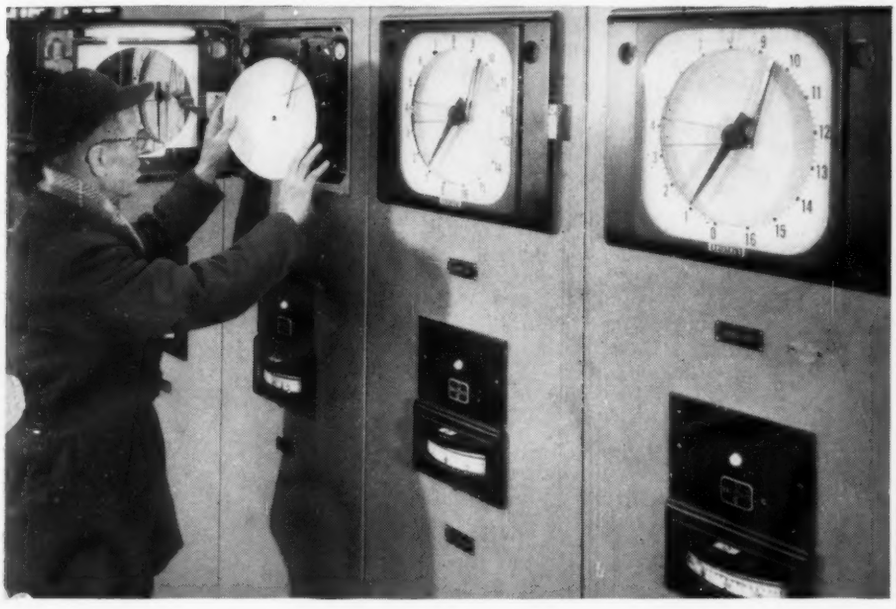
A Bristol Dynamaster high-speed temperature recorder transcribes test results in the Westinghouse Elevated Temperature Structures Test Facility shown here during its development.

The system is designed to test aircraft and missile structures under temperature conditions simulating flight through the air at speeds up to 5000 mph. The equipment can produce temperatures of 2650° F in 13 seconds. Desired temperature-versus-time programs can be simulated with great accuracy.



NEWS AND NOTES

RECORDING INSTRUMENTS FOR THE METAL-WORKING INDUSTRY ★



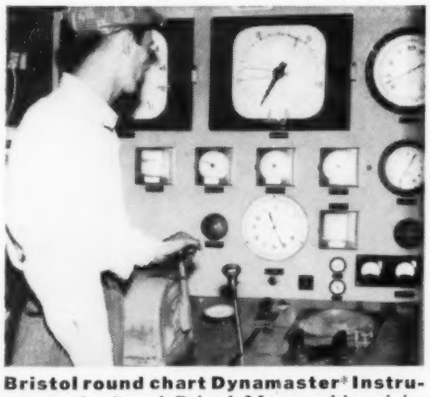
Instruments help turn out casting cores at 7 tons/hour

Engine blocks for Ford and Mercury automobiles are cast with strictest attention to accuracy and structural quality at the Cleveland foundry of the Ford Motor Company, Brookpark, Ohio, just outside Cleveland.

Yet these rigorous requirements must not impede the smooth flow of the production line. That's one reason Ford installed this battery of Bristol Dynamaster* instruments.

Another: In the early days, core baking used to be an all-night process. Cores were of fine quality, but the output was too low for present-day production lines. The new core baking method turns out top quality cores at the rate of 7 tons an hour. Bristol instruments automatically hold the baking temperature to 450° ± 5°F. And, in emergencies, allow faster processing by raising the temperatures and increasing conveyor speed.

First oxygen steel plant uses Bristol controls



Bristol round chart Dynamaster* Instruments (top) and Bristol Metagraphic miniatures (center row) play a big part in controlling oxygen steel-making at Dominion Foundries & Steel, Ltd.

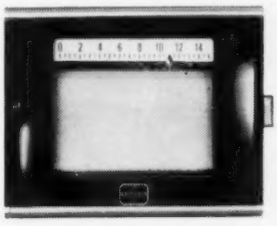
When Dominion Foundries & Steel, Ltd. (Dofasco), at Hamilton, Ontario, first introduced this method of steel-making to the North American Continent, they chose Bristol instruments and controls (above) to supervise the most critical steps in the process.

These include oxygen pressure and flow (current rate and total), lance position, lance cooling water temperature, flow, and pressure as well as various other temperatures.

The big advantage of oxygen steel-making is the lower original investment in equipment. Only about 50% of the equipment costs of competitive processes is required and operating costs are no higher, with equal or better product.

Furnace, oven, dryer— Bristol controls them all

Whatever your industrial heating application, you can find a Bristol instrument or instrument system to provide precision indication, recording or automatic control. The following instruments, in almost innumerable variations, are typical of the truly complete Bristol instrument line.



Bristol's Dynamaster* Potentiometer Pyrometers come in round or strip chart models, provide electronic recording, indication, and electric or pneumatic control, including high-low contact, proportional, time-program and many combinations. The outstanding instrument for maximum precision.

Bristol Millivoltmeter Pyrometers. Both indicating and controlling models available. Controlling models utilize unique Bristol Free-Vane* principle that completely eliminates relay "chatter" or "flutter." High-low contact and proportional models available in a wide variety of combinations.

Bristol Miniature Instruments – Bristol is the only company offering a complete line of instruments in both miniature *and* full-size for all recording, indicating and control applications, both electronic and pneumatic. True plug-in construction. Ideal where panel space must be conserved.

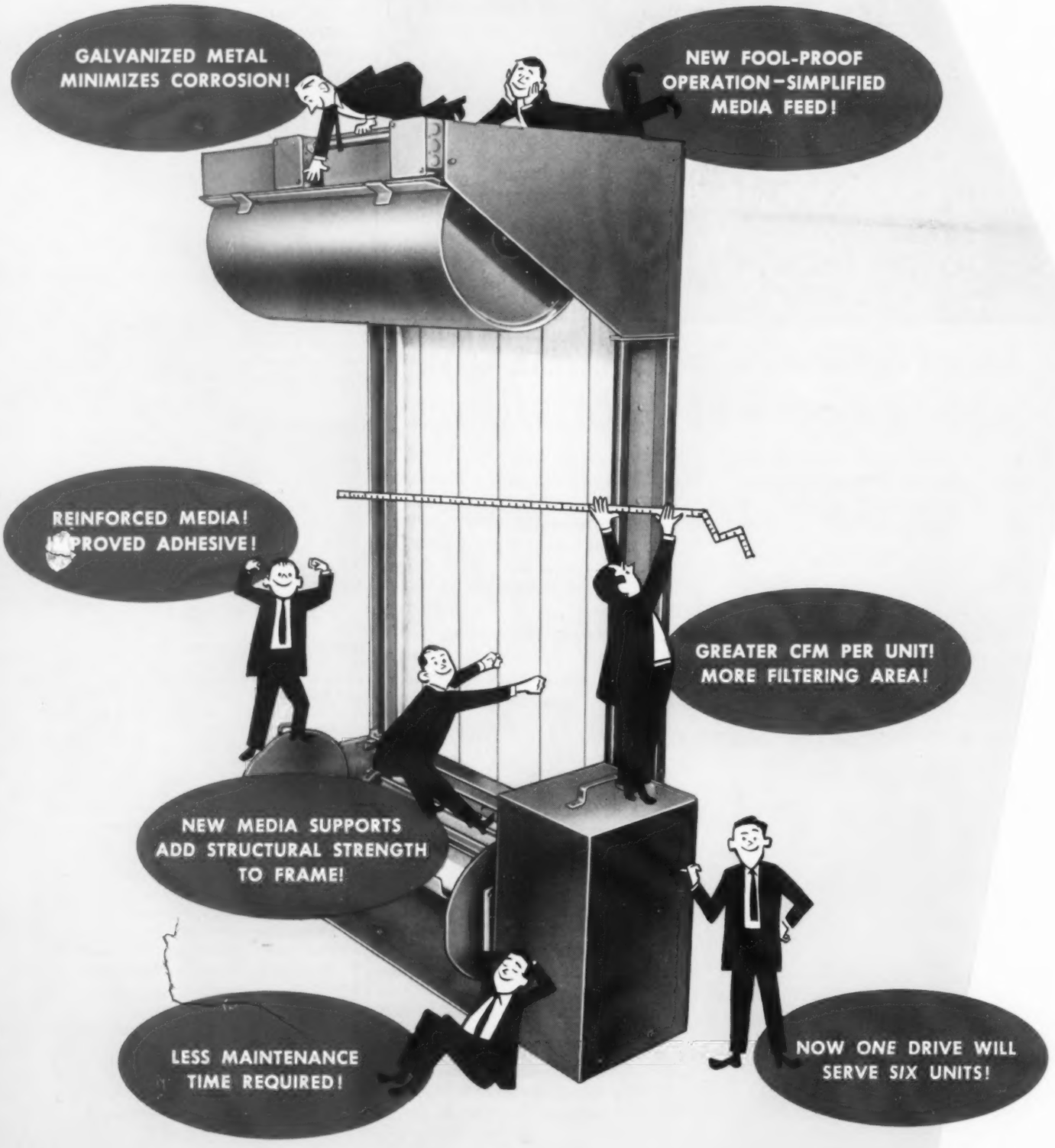
*T. M. REG. U. S. PAT. OFF.

Write for complete data on Bristol instruments for your furnace, oven, dryer or kiln. And remember, Bristol makes a complete line of thermocouples and pyrometric accessories. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn.

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

NEW! AAF model B


GALVANIZED METAL MINIMIZES CORROSION!
NEW FOOL-PROOF OPERATION–SIMPLIFIED MEDIA FEED!
REINFORCED MEDIA! IMPROVED ADHESIVE!
GREATER CFM PER UNIT! MORE FILTERING AREA!
NEW MEDIA SUPPORTS ADD STRUCTURAL STRENGTH TO FRAME!
LESS MAINTENANCE TIME REQUIRED!
NOW ONE DRIVE WILL SERVE SIX UNITS!

Roll-O-MATIC® AIR FILTER!

RETAINS *ALL* THE FEATURES of the amazing AAF Roll-O-Matic that have led to installation of thousands of sections at 2,100 locations since 1954—totalling more than 100 million cfm!

- Clean air by the roll!
- As simple to service as a roll-fill camera!
- Infrequent maintenance!
- No oil or water for washing!
- High cleaning efficiency!
- Large dust-holding capacity!
- Fully automatic!
- Simple disposal of used media!
- Notifies operator when needing attention!
- Low power requirements!

and offers *these* big IMPROVEMENTS

✓ **Stronger MEDIA!** Unique Roll-O-Matic filtering media is now reinforced for greater strength. New adhesive (1) won't "run" in high temperatures, (2) won't thicken in low temperatures, and (3) won't lose adhesive qualities due to dryness.

✓ **Simpler OPERATION!** Positive drive for introducing new media and re-winding used media. Minimum of moving parts.

✓ **Easier MAINTENANCE!** Non-corrosive frame, simpler operation, stronger media, better adhesive, re-location of drive all add up to fewer maintenance headaches.

✓ **Greater CFM!** Now, more media area, more CFM per filter! New design provides maximum effective filtering area per unit.

✓ **Rugged, heavy-duty DRIVE!** Drive is now on service side of unit for easier accessibility. Fractional hp. drive will serve six units of maximum standard height and width. Means big savings in first cost, installation, and operation.

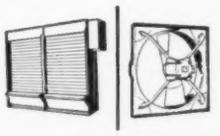
✓ **Corrosion-resistant CONSTRUCTION!** The Model B Roll-O-Matic is constructed of galvanized metal . . . minimizes corrosion problem. New media supports add to structural strength of frame in addition to serving as media guides.

WRITE TODAY FOR NEW ROLL-O-MATIC BULLETIN 248-C!

AAF herman nelson

American Air Filter
COMPANY, INC.
302 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

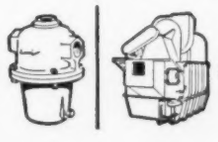
AAF Filters and Precipitators



Herman Nelson Propeller Fans

BETTER AIR IS OUR BUSINESS

Illinois Heating Specialties

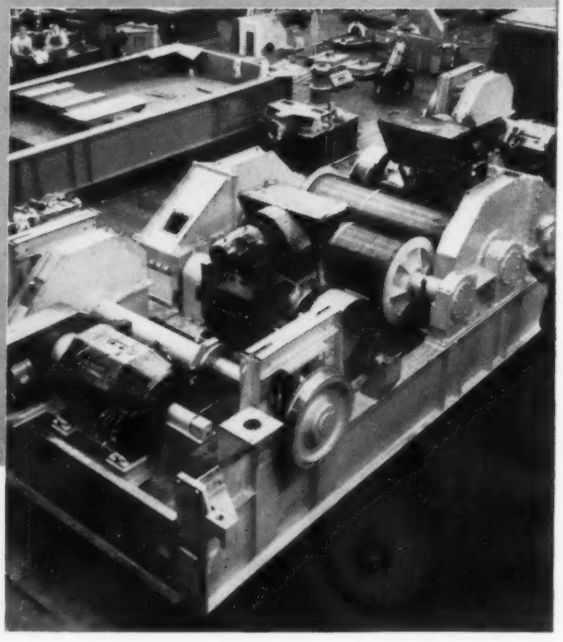


AAF DUST Control Equipment

MAKE SURE YOUR NEXT BULK MATERIALS UNLOADER HAS THESE IMPORTANT DRAVO FEATURES:

- **Greater Rigidity of Structure through Use of Rolled Sections**
- **Positive Wind Protection with Dravo Rail Clamps**
- **Fully Equalized Loading on Truck Wheels**
- **Trolley Accident Prevention with Dravo Hydraulic Buffers**
- **Use of Unit Construction for Mechanical Elements**

LIBERAL USE OF WELDED COMPONENTS



Shop Assembly of Welded Man Trolley—accurate alignment is always assured as welds will not loosen. All connections are sealed, maintenance is simplified and hidden corrosion avoided.

DRAVO Unloaders...

welded construction used to assure strength and rigidity

The use of welded construction at key points is one of the many features which add to the life and usefulness of Dravo bulk materials handling equipment. Many other operating economies result from the fact that each structure is individually designed to handle its specific job economically, dependably and safely. Such performance is achieved by bringing together the customer's operating knowledge and the experience of Dravo's research, design and construction men.

This method has resulted in high efficiency unloaders and other bulk materials handling equipment that produce because they are tailored to fit the job. Dravo engineering features, built into every structure, provide for low maintenance and operating costs. For complete information write to Dravo Corporation, Pittsburgh 25, Pa.

DRAVO
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

Approximate Service Limit Brand
3200°F. Castolast (Castable)
3100°F. H-W High Alumina Castable
Apache (Plastic Fire Brick)
3000°F. Chromepak (Casting Mix)
H-W Super Plastic Fire Brick
Apache G (Plastic Fire Brick with Graphite added)
2900°F. H-W Black Patch (Plastic Fire Brick)
2800°F. Harcast (Castable)
2700°F. H-W Super Castable
2600°F. H-W Lightweight Castable 2600
Harchrome (Castable)
H-W Chrome Castable
2500°F. H-W Standard Castable
H-W Periklase Castable
H-W Baffle Mix (Castable)
2400°F. H-W Extra Strength Castable
2300°F. H-W 85 Lightweight Castable
2200°F. H-W 56 Low Iron Castable
H-W 56 Lightweight Castable
1800°F. H-W 25 Lightweight Castable
1500°F. H-W Castable RC

The complete series of HARBISON-WALKER PLASTIC and CASTABLE REFRACTORIES

can assure the proper selection for maximum life and economy

In addition to the wide range of service temperature limits as here illustrated, these monolithic refractories possess the many different combinations of physical and chemical properties needed for best protection against widely diversified destructive factors. From these brands the best balanced selection can be made for adequately withstanding the most severe operating conditions. Some examples of the many destructive influences against which maximum resistance is needed, are: corrosion by slags, fuel ash and various other fluxes; thermal shock; disintegrating action of gases; erosion by molten metals and slags; mechanical stresses at the high working temperatures.

To help secure maximum service from these refractories, Harbison-Walker freely offers engineering service, recommendations based upon wide experience, and quality-controlled products.

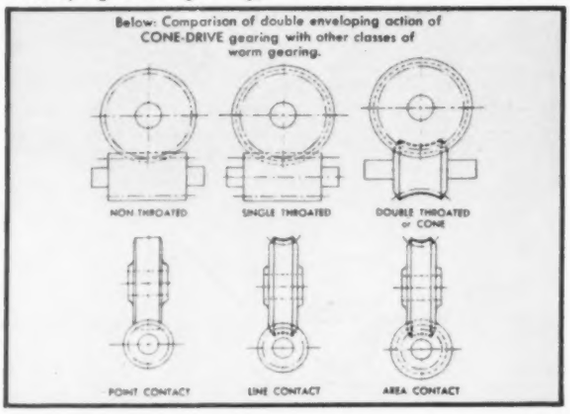
HARBISON-WALKER REFRACTORIES CO.
AND SUBSIDIARIES GENERAL OFFICES: PITTSBURGH 22, PA.
World's Most Complete Refractories Service

TYPICAL FURNACE APPLICATIONS: ARCHES • ASH PITS • BOILER SETTINGS • BREECHINGS • BURNER BLOCKS • BAFFLES • CATALYTIC REACTORS • DOOR LININGS • DUCTS AND PIPING • HEARTHS • INSULATION • KILNS AND CARS • LADLE LININGS • ROTARY KILN CHAIN SECTIONS • SOAKING PIT COVERS

TEAR OUT AND MAIL IN FOR COMPLETE DATA

How to get the most out of Worm Gearing

If a right-angle drive is needed in your product and you require maximum capacity for your dollar, then the Cone-Drive double-enveloping type will give it to you. The sketch below shows the apparent advantages of Cone-Drive gearing as compared to other worm gear types. Double-enveloping worm gearing, the most modern and efficient

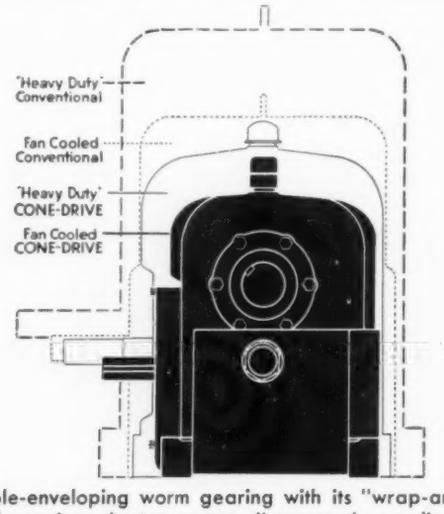


Below: Comparison of double enveloping action of CONE-DRIVE gearing with other classes of worm gearing.

form, has straight-sided teeth in both worm and gear. Both elements of Cone-Drive are throated and envelop each other, providing a multiple tooth area contact. This means greater load-carrying capacity than is possible with any other type of worm gearing.

Double-enveloping worm gearing is available from Cone-Drive Gears in complete lines of gearsets, speed reducers and gearmotors. Gearsets are stocked in center distances from 2" thru 24", capable of handling loads from fractional to over 1600 horsepower. A complete line of mountings for gearsets is also stocked.

Speed reducers and gearmotors with Cone-Drive double-enveloping worm gearing are unusually compact and powerful drives that handle shock loads with ease. Yet, they provide power transmission smoother than that of hydraulic systems. Another advantage, unique to double-enveloping worm gearing, is their ability to regenerate themselves when wear occurs. Both worm and gear tend to reproduce the correct form in the other when wear occurs.



Double-enveloping worm gearing with its "wrap-around design" requires shorter center distances than cylindrical worm gearing to handle the same loads. As a result, Cone-Drive speed reducers have smaller housings with corresponding savings in weight and space. Bulky gear trains can often be replaced with a single Cone-Drive speed reducer or gearset.

DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road • Detroit 12, Michigan
Telephone: TWinbrook 1-3111

Please send me information on following:

☐ Gearsets ☐ Gearmotors ☐ Speed Reducers

Name_____

Title_____

Company_____

Street_____

City_____ State_____

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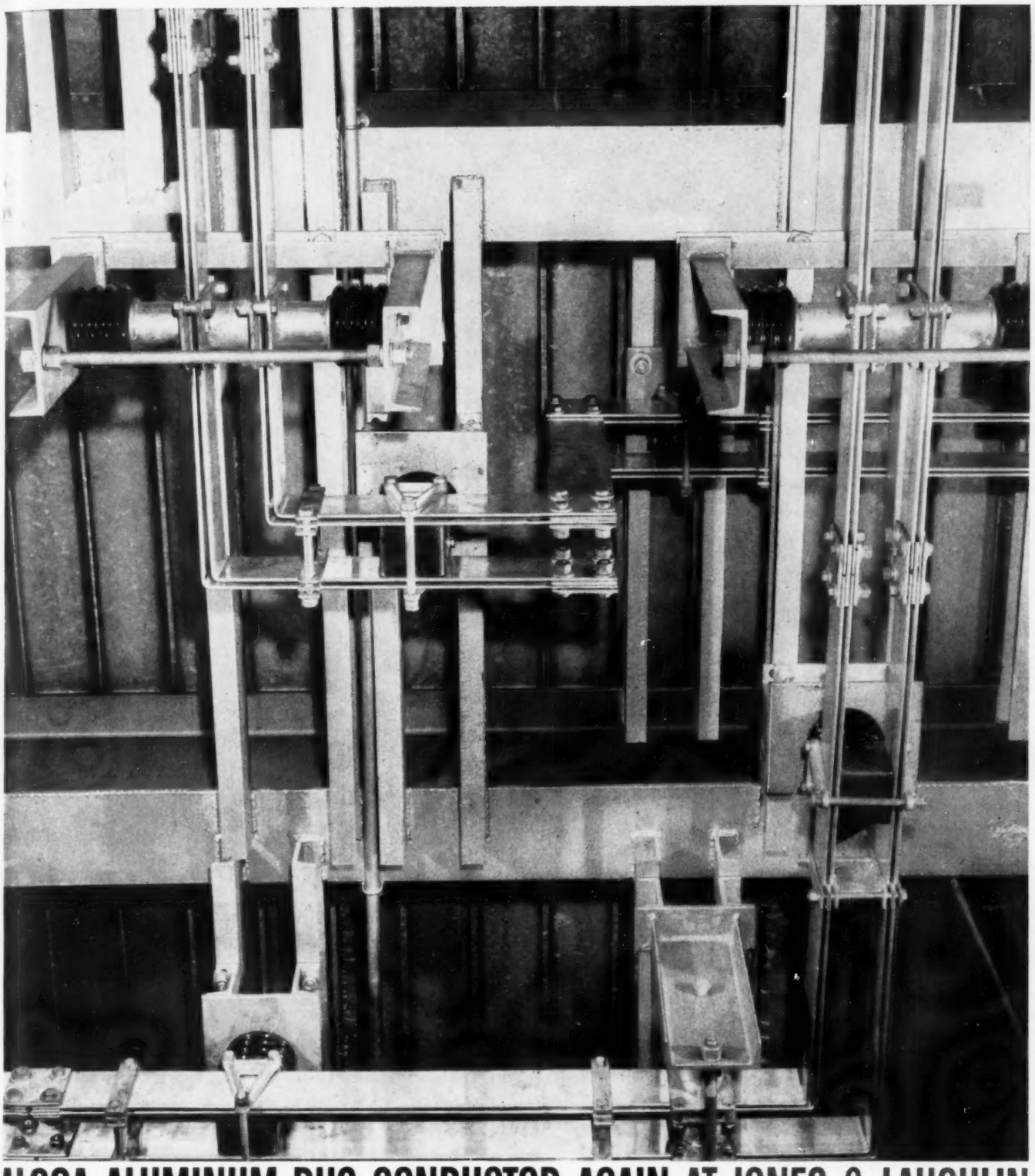


ALCOA ALUMINUM BUS CONDUCTOR AGAIN AT JONES & LAUGHLIN

Jones & Laughlin Steel Corporation *again* used Alcoa® Aluminum Bus Conductor in their Aliquippa, Pa., Hot Strip Mill and saved almost 50 per cent over a comparable copper installation.

The 21-year record in a hot strip mill at their Pittsburgh Works had already proved the satisfactory performance of Alcoa Aluminum Bus Conductor.

Low material cost, low installation and maintenance costs plus easy-to-make, low-resistance connections are strong reasons to use Alcoa Aluminum Bus Conductors in the steel industry. Immediate delivery of rectangular bus conductor in popular sizes is available from your Alcoa Distributor. Call him before completing plans for plant modernization or expansion. Or write, Aluminum Company of America, 2310-L Alcoa Building, Pittsburgh 19, Pa.

DISTRIBUTORS OF ALCOA ALUMINUM BUS

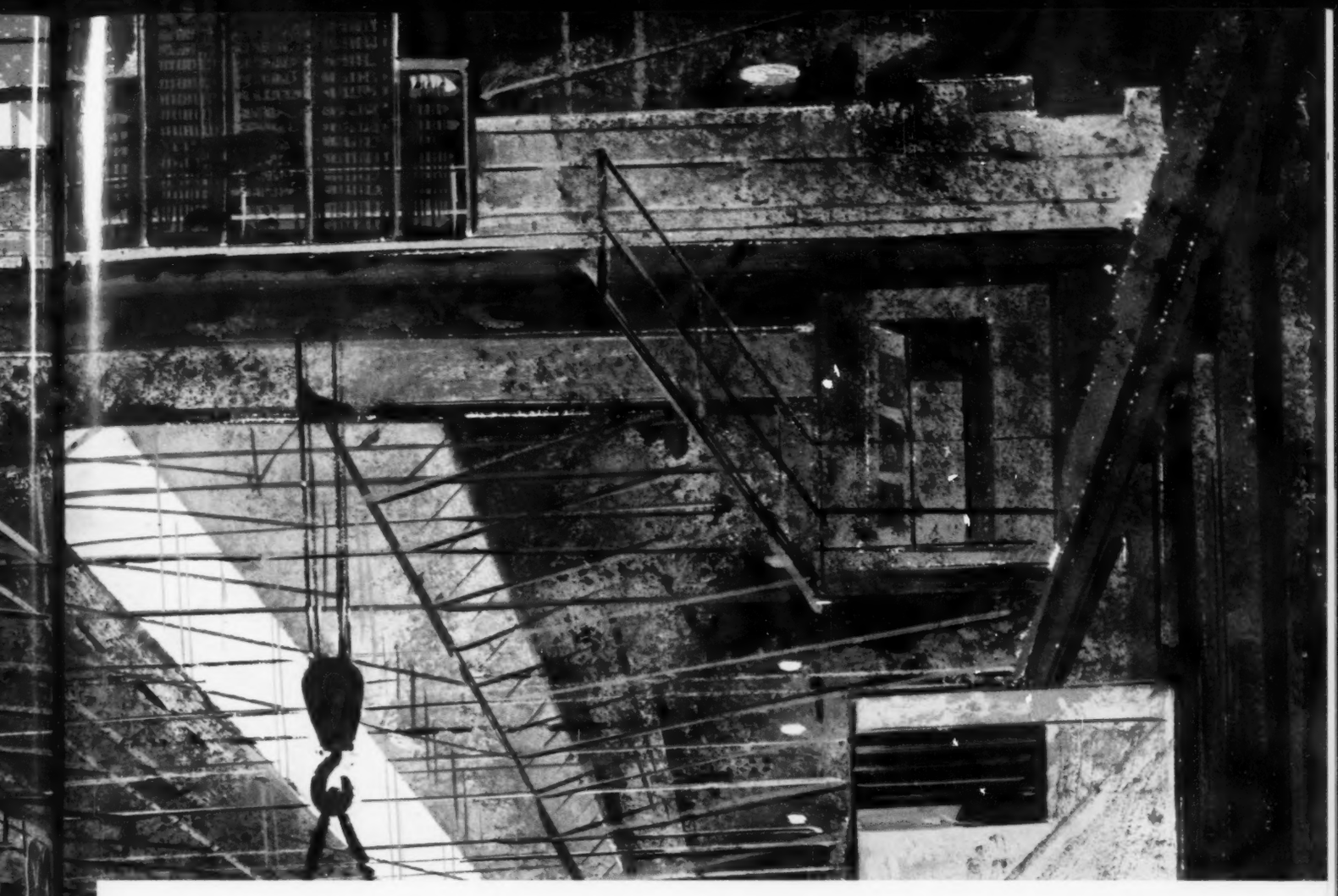
Brace-Mueller-Huntley, Inc. — Pacific Metal Co.
The Corey Steel Co. — Pacific Metals Co., Ltd.
Edgcomb Steel Co. — The J. M. Tull Metal & Supply Co., Inc.
Ducommun Metals & Supply Co. — Williams & Co., Inc.
Metal Goods Corp. — Whitehead Metal Products Co., Inc.

Four ¼" x 6" Alcoa Aluminum Bus Bars carry 5,000 amps maximum at 750 volts to finishing stand motors at Jones & Laughlin's Aliquippa Works.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM
ELECTRICAL CONDUCTORS AND ACCESSORIES

ALCOA THEATRE
Fine Entertainment
Alternate Monday Evenings



You can save as much as 60%
on bearing maintenance costs

We know roughly 25 iron and steel plant applications where bearing and other bronze parts may be costing you too much. Here are a few:

Crane truck and trolley bearings • Table roll bearings • Manipulator bearings • Ore bridge bearings • Tilting table bearings • *also* Liners • Slide guides • Peeler nuts.

For applications like these, NBD makes a special kind of casting—long lasting, efficient, perfect for the service, but much less expensive than machined bearings or parts.

We call these castings *precision cast-to-size.* They cost you less because no one ever puts a machine tool to them (except for drilling and tapping). Oil grooves are cast in.

You can have your choice of alloy. Or take our recommendation.

Size and weight are not a problem. We'll cast your bearings or other parts ready to use as you receive them.

Let's talk about costs and applications in your mill. Call or write.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
717 Grant Building • Pittsburgh 19, Pennsylvania
PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

PROOF: Shaw-Box can build cranes to your specs (or AISE)

Every steel mill has its own special materials handling problems. Problems which could be handled by standard crane designs 30 years ago now demand cranes built to specifications unique to a single mill.

These ten leading steel companies developed their own crane specifications (or chose modern AISE standards.) Each awarded the job of constructing the crane to Shaw-Box.

REASON: Shaw-Box can produce *any* type of crane of *any* capacity. We are not bound by traditional concepts of design. Usually, we can offer better delivery. Control of Shaw-Box Cranes is a miracle of precision and speed.

When your company next prepares specifications for a crane — of any type — make sure they are sent to Shaw-Box.

58K-1

"Shaw-Box"® CRANES

MANNING, MAXWELL & MOORE, INC.
SHAW-BOX CRANE & HOIST DIVISION
388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments.

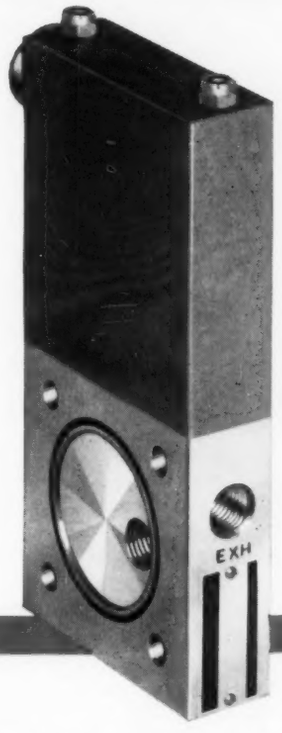
In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario.*

Introducing the new

HUNT

Slim Line
VALVES

SOLENOID, SINGLE PILOT
DOUBLE PILOT, LEVER
OR BALL ACTUATED



ONLY 1″ THICK BY 3″ WIDE

Compact, light in weight, and easily manifolded, these new Hunt valves have been designed specially for use when mounting space is limited. Ideally suited for controlling small cylinders, or to operate diaphragms, pilot cylinders or other devices. Pressures to 125 psi.

Proven, dependable Hunt construction, with hollow, radially ported stainless steel plunger; and "O"-ring seals accurately positioned with metal spacers, held rigidly in metal to metal end abutment. No lapped joints and no rubbing of metal against metal to cause wear, assuring long, efficient, maintenance-free operation.

Easily manifolded. The side of each valve is counterbored; trepanned for an "O"-ring and provided with four through holes. This permits up to eight valves to be manifolded together in any of four 90° angle positions, and operated simultaneously from a single supply;— or up to sixteen valves from two supply sources.

More startling HUNT designs to come!

Send for the "SLIM LINE" Bulletin No. 581 TODAY!

HUNT

Quick-As-Wink® AIR AND HYDRAULIC CONTROL *Valves*

Manufactured by HUNT VALVE COMPANY, 1922 East Pershing St., Salem, Ohio

THIS "CLOCK" is not a timepiece. But it's an impressive example of the precision cutting possible with Messer equipment. All of the figures, offsets, and other features of this dial were cut automatically guided by a photocell with an oxygen cutting machine out of ⅜ inch plate. The dial indicator is actually installed on a heavy forming press in a large steel mill.

Around the clock...

MESSER CUTTING MACHINES PERFORM NEW MIRACLES IN AUTOMATIC PRECISION CUTTING

Isn't it "time" you thought about the money-saving advantages you can get through the use of the new and revolutionary cutting techniques now possible with *Messer Cutting Machines?*

INCREASE YOUR PROFITS

Experience has shown that the Messer cutting machine versatility of design permits greater shop flexibility and the increased use of automation. The result? Lower costs, lower waste, GREATER PROFITS.

This unique oxygen cutting equipment features a completely engineered system of operation. This leads to new high standards in precision workmanship and greater accuracy.

ASK US FOR MORE DETAILS!

In steel mills, in shipyards—wherever cutting machines are used—Messer equipment can increase efficiency. It will pay you to find out *now* what Messer can offer you. Write us for full information. No obligation, of course. Messer Cutting Machines, Inc., Chrysler Building, 405 Lexington Avenue, New York 17, N.Y.

Messer Cutting Machines

WELDING ENGINEERING SINCE 1898

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period June 3, 1958 through June 17, 1958.

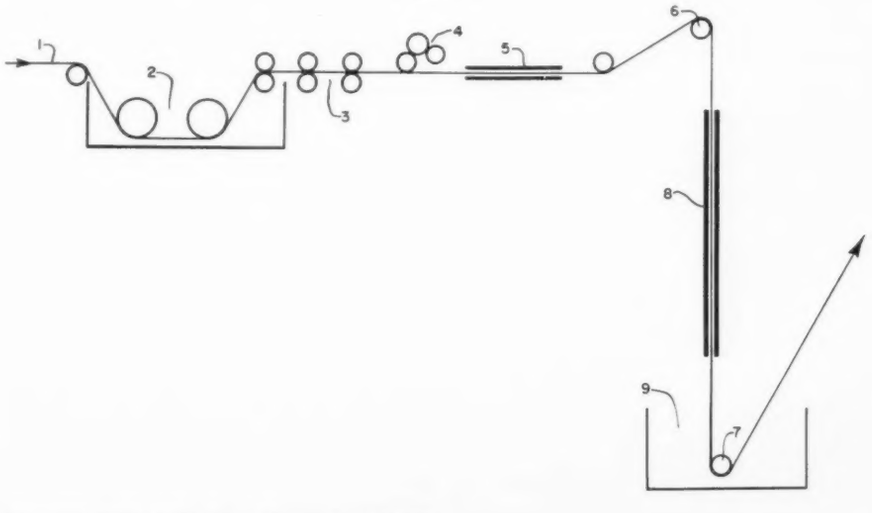
PRODUCTION OF A DULL FINISHED FUSED TIN COATING

△ U. S. 2,839,437, issued June 17, 1958, to Joseph M. Manko, assigned to Jones & Laughlin Steel Corp., describes a thermochemical method of treating electrolytic tin plate to maintain a dull surface on it during and after reflowing of the tin.

As shown in Figure 1, the matte finish strip 1 from the electroplating apparatus is passed into a tank 2 which contains a hot rinse solution. From tank 2 the strip 1 passes through wringer rolls 3 which remove excess rinse solution and then to roller coater apparatus 4 which applies the oxidizing agent, a dilute aqueous solution of sodium nitrite, to the surface of the strip. The strip then passes through a dryer 5, in which the water from the treating solution is evaporated. The treated strip 1 then passes over a horizontal roll 6 and vertically downward through flow-brightening apparatus 8, which may be induction heating means, and into a tank 9 provided with quenching liquid where it passes under a horizontal roll 7 in the quench tank and then upwardly outward.

The surface of the tin exhibits a dull appearance, which is readily distinguished from bright tin plate by its silvery or satin finish luster.

Figure 1



REDUCTION OF IRON ORE WITH CARBON MONOXIDE AND HYDROGEN

△ U. S. 2,837,419, issued June 3, 1958, to Frederick B. Sellers and Peters L. Paull, assigned to Texaco Development Corp., describes a process for the production of metallic iron or pig iron, by the reduction of iron ore with carbon monoxide and hydrogen. Part or all of the coke requirement is eliminated.

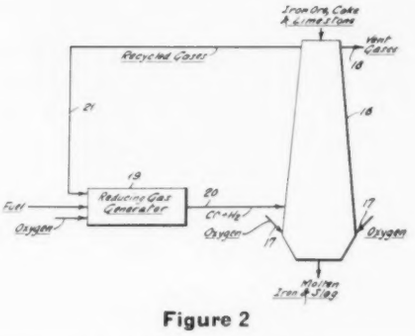


Figure 2

Figure 2 shows the application of the process to the production of pig iron in a conventional blast furnace. A blast furnace 16 is charged with a mixture of iron ore, coke and limestone. Less than the usual amount of coke is used which, in turn, reduces the limestone requirements. Thus the charge to the furnace is richer in iron ore than is the charge to the conventional blast furnace. Molten iron and slag are tapped from the lower portion of the blast furnace in the usual manner. Air or other oxygen-containing gas, preferably relatively pure oxygen, is introduced to the blast furnace through the usual tuyere 17. Gases are vented from the upper end of the furnace through line 18.

A stream of reducing gas, consisting of carbon monoxide, is generated in a reducing gas generator 19 by partial combustion of a carbon-containing fuel with an oxy-

gen-containing gas, preferably relatively pure oxygen. These gases are introduced through line 20 into the blast furnace at an intermediate point, above the point of introduction of air. A part of the gases may be recycled from the upper portion of the blast furnace through line 21 to the reducing gas generator. These gases contain carbon dioxide and water vapor resulting from oxidation of hydrogen and carbon monoxide with oxygen given up by the ore. In the reducing gas generator, the carbon dioxide and water vapor are again converted to carbon monoxide and hydrogen.

REMOVAL OF HCN, H_2S AND NH_3 FROM COKE OVEN GAS

△ U. S. 2,837,398, issued June 3, 1958, to Otto Grosskinsky, Heinrich Fruhbuss and Walter Klempt, describes a process for removing HCN, H_2S and NH_3 from coke oven gas with reduced corrosion of the equipment because of prior removal of the hydrocyanic acid from the gas.

As shown in Figure 3 the hot raw gas enters receiver 1 from which it is passed to the cooler 2, through the gas exhauster 3 and to the final cooler 4. The cooled gas is then passed through the electrical detarring apparatus 5 where it is substantially completely detarred. The detarred and cooled gas is passed through the dry purifiers 6 and 7. The purifiers 6 and 7 are charged with bog iron ore, or Lux-mass (which is the residue from bauxite treatment), the latter being preferred because of its alkali content which favors the rate of reaction.

The removal of the hydrocyanic acid from the gas is accomplished with ferrous sulphide which has a high ability for removal of the hydrocyanic acid and which reacts with hydrocyanic acid in the presence of ammonia according to the following equation:

$$FeS + 4NH_3 + 6H(CN) \rightarrow (NH_4)_4Fe(CN)_6 + H_2S$$

In addition, insoluble ferrocyanides such as Prussian blue are formed.

During the process, iron salts other than ferrous sulphide are generally first converted to ferrous sulphide and the ferrous sulphide then acts to remove the hydrocyanic acid from the coal distillation gas. For example ferric hydroxide is reduced and sulphided according to the following equation:

$$2Fe(OH)_3 + 3H_2S \rightarrow 2FeS + S + 6H_2O$$

This reaction is favored by the influence of ammonia which is present in the cooled coal distillation gases in about 60 per cent of the original ammonia content and in general in an amount of about 2 to 8 gram ammonia per cubic meter of gas.

In purifier 6 the hydrocyanic acid is bound. In purifier 7 the iron compounds are sulphided by the hydrogen sulphide gas and ferrous sulphide is formed. As soon as purifier 6 allows the hydrocyanic acid to pass through without binding all of the hydrocyanic acid, it is filled with fresh dry purification masses and inserted behind the purifier 7. Thus, the purifier 7 which now contains ferrous sulphide removes the hydrocyanic acid from the gas and the freshly charged purifier 6 is sulphided by the hydrocyanic acid-free gas. This process is carried on continuously.

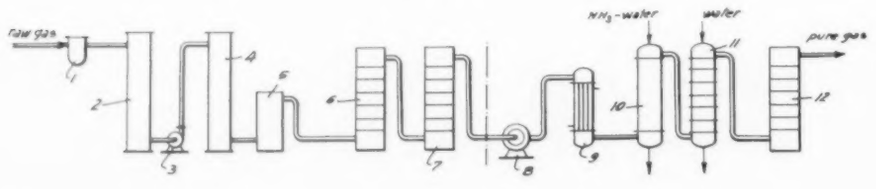
The gas freed from hydrocyanic acid and from some hydrogen-sulphide which has sulphided the dry purification mass in purifier 7 is compressed in compressor 8, cooled again in cooler 9 and then freed from hydrogen sulphide and ammonia in scrubbers 10 and 11. Finally, the gas passes, if necessary, once more through a dry purifier 12 in which any remaining hydrogen sulphide is absorbed.

SEPARATION OF ACID GASES FROM COKE OVEN GAS

△ U. S. 2,837,399, issued June 3, 1958, to Herbert A. Gollmar and Walter M. Africa, assigned to Koppers Co., Inc., describes improvements in the hot vacuum actification process for the removal of acid gases such as H_2S, HCN and CO_2 from coke oven gas.

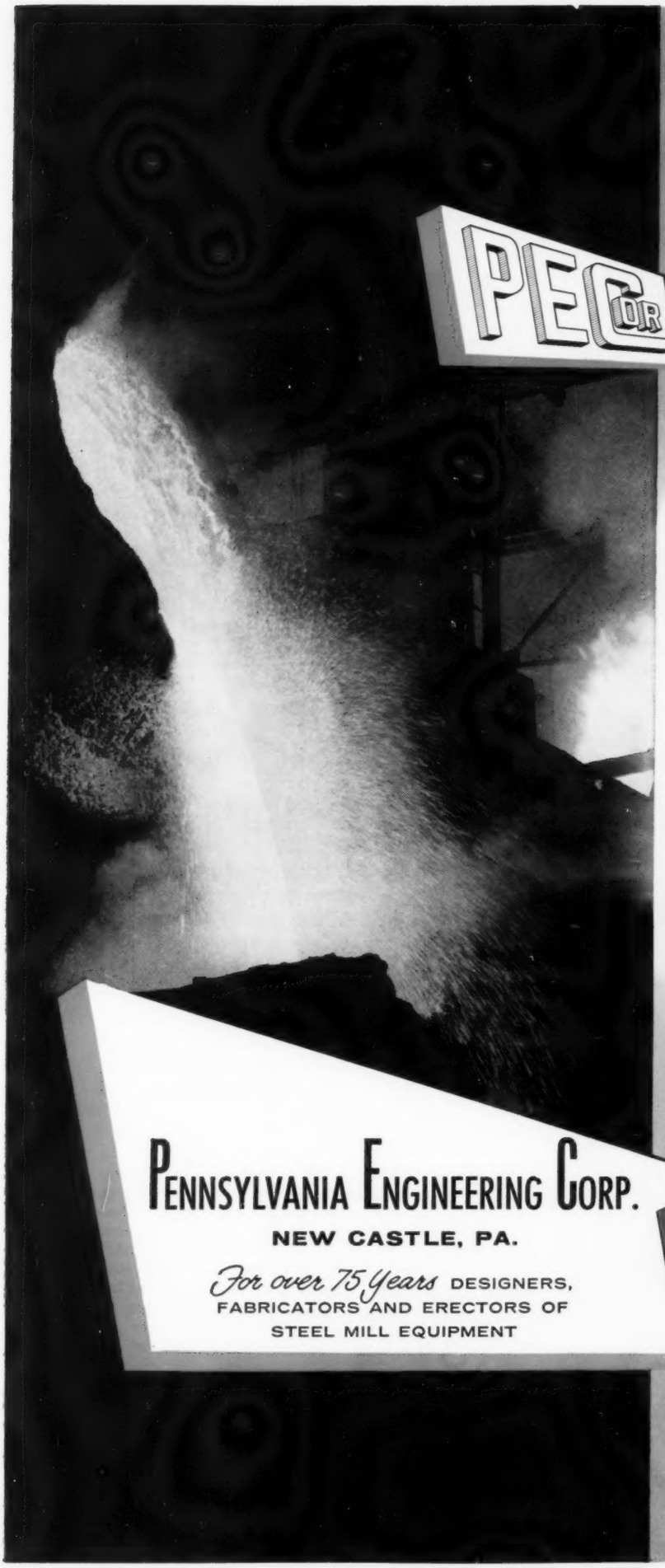
This invention is based on the

Figure 3



OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,836,866	6/3/58	Pouring ladle for metals	General Steel Castings Corp.
2,836,880	6/3/58	Flying hot saw	The Aetna-Standard Engineering Co.
2,837,044	6/3/58	Soaking pit covers	Levi S. Longenecker
2,837,157	6/3/58	Billet shears	Industrie-Werke Karlsruhe A.G.
2,837,200	6/3/58	Bar and billet turning apparatus	Evans Enterprises, Inc.
2,837,295	6/3/58	Metal strip uncoiler	The McKay Machine Co.
2,837,326	6/3/58	Charge supporting means for furnaces	General Electric Co.
2,837,331	6/3/58	Apparatus for grinding strip into a pinhole detector	United States Steel Corp.
2,837,421	6/3/58	Die steel alloys	National Lead Co.
2,837,422	6/3/58	Addition agents for the treatment of molten cast iron	Metallgesellschaft A.G. et al.
2,837,470	6/3/58	Coke quenching	Hayden & Co.
2,837,945	6/10/58	Bar steadier for seamless tubing mills	United States Steel Corp.
2,838,165	6/10/58	Device for holding coils of strip metal	Alvin F. Groll
2,838,184	6/10/58	Apparatus for clamping and turning a pile of sheets	United States Steel Corp.
2,839,286	6/17/58	Checker construction for open hearth furnaces	Clarence G. Poth
2,839,290	6/17/58	Soaking pits	Selas Corp. of America
2,839,291	6/17/58	Sintering apparatus	United States Steel Corp.
2,839,295	6/17/58	Stop for double-draft piling of sheets	United States Steel Corp.
2,839,324	6/17/58	Device for turning suspended loads	United States Steel Corp.
2,839,369	6/17/58	Ammonia still apparatus	Koppers Co., Inc.
2,839,382	6/17/58	Refining of metals	Huttenwerk Oberhausen A.G.
2,839,393	6/17/58	Addition agent for cast iron	The International Nickel Co., Inc.
2,839,453	6/17/58	Coking retort oven with graduated liner wall	Koppers Co., Inc.
2,839,454	6/17/58	Coking retort oven	Koppers Co., Inc.



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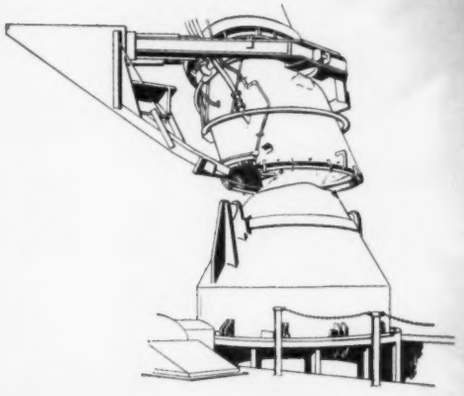

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discovery that polymerization occurs in the pump by virtue of heat generated when the acid gases, at the high vacuum that is necessary to release them from the alkaline absorption solution in the actifier, are compressed to the pressure required to propel them to the point of utilization. Hydrogen sulphide, and hydrogen cyanide passing through the pump, possibly with other contaminants, form hard polymers at temperatures resulting from a high pump compression ratio. In accordance with this invention, when HCN is desired, high compression ratios are reduced and, while there is some formation of liquid polymer, formation of hard polymers is substantially eliminated.

CASTING OF STEEL INGOTS

△ U. S. 2,837,800, issued June 10, 1958, to Shigeo Hachiya, Tatsuhei Uchiyama and Masumi Aihara, assigned to Yawata Iron & Steel Co., decribes a method for casting steel ingots in which peripheral blowholes are eliminated, to produce a more perfect steel ingot than heretofore possible, particularly for rolled products.

Figure 4 shows a treating or agitator pipe 3 consisting of an elongated pipe of steel 2 to 2.5 meters in length, ½ to 1 inch in diameter, having a degasifying agent 6 such as finely divided or granular aluminum filling the end. The quantity of aluminum depends upon the quantity of the metal to be treated. The other end of the agitator is handled by an operator.

Figure 4 also shows a bottom-poured killed steel ingot casting apparatus which consists of a big-end ingot mold 1, a shrink head casing 2, a runner 4, and a base-plate 5. The aluminum 6 is dissolved and reacts with occluded gases in the molten metal 11 in the mold 1. Figure 5 shows, by means of arrows, the course along which the agitator 3 is moved.

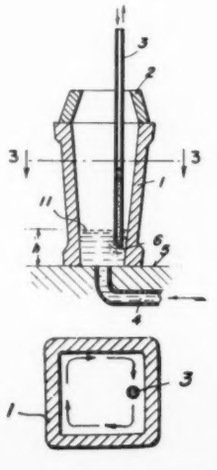

Figure 4

Figure 5

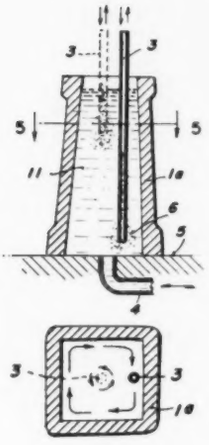

Figure 6

Figure 7

Figure 6 shows a bottom-poured rimmed steel ingot casting apparatus which consists of a big-end-down ingot mold 1a, a runner 4, and a base-plate 5. The aluminum 6 is dissolved and reacts with occluded gases in the molten steel 11 in the mold 1. Figure 7 shows, by means of arrows, the course along which the agitator is moved in the periphery and the center.

In the practice of the invention with reference to Figure 4, when molten steel 11 is teemed into the bottom-poured big-end-up ingot mold 1 through runner 4, and at the beginning or at the latest at the time when the teeming of molten metal reaches one-half of the predetermined amount, the agitator pipe 3 is pushed to a shallow extent into the molten bath level. Skin blowholes 7 are formed in the inner periphery of a killed steel ingot, so that various gases contained in this portion of molten steel 11 can be removed by the effective degasification or deoxidization treatment according to the invention, that is, by the application of the stirring pipe 3 along the inner periphery of molten metal in the mold in such manner that the stirring pipe is moved while agitating along the inner periphery of the molten steel, as shown by the arrow in Figure 5, coming into close contact with the mold, and then the agitator is lifted upwards as the molten steel rises in the mold while being stirred continuously. In the course of the agitation, aluminum powder at the end of the pipe 3 is continuously dissolved in the molten metal and reacts with the occluded gases, such as oxygen, carbon monoxide, nitrogen, etc., in the metal, whereby the gases are eliminated continuously in the treated local portion of the metal. When almost all the molten steel has been teemed in the mold, agitation is discontinued, and the agitator is lifted above the metal bath level. With the above procedure, the occluded gases which result in skin blowholes can be removed.

In reference to Figure 6 the application of this invention to the casting of rimmed steel ingots in the bottom-poured ingot mold is as follows: when molten steel 11 has been teemed through runner 4, and filled to the predetermined height in the mold 1, the agitator pipe 3 is introduced immediately into the bottom portion of molten metal; first, molten steel 11 is agitated by the treating pipe 3 in the lower central peripheral portion in order to remove unfavorable tubular gas pockets 8 shown in Figures 8 and 9; secondly, the treating pipe 3 is immediately moved to the upper central portion of the molten steel where inner segregations and gas pocket group 10 are formed, while being agitated. The arrows in Figures 6 and 7 show how to agitate the molten steel effectively by the treating pipe, that is, the pipe is lifted gradually upwards while the steel is being agitated.

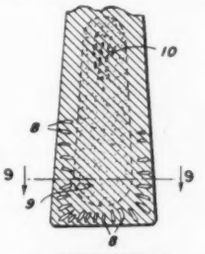

Figure 8

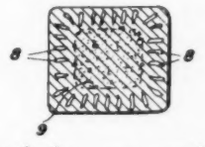

Figure 9

As agitation proceeds, powdered aluminum 6 is continuously dissolved in the molten steel to react with the occluded gases in the molten metal, whereby such gases are continuously removed from the treated portions of the ingot.

METHOD FOR DRYING METAL SCRAP

△ U. S. 2,836,901, issued June 3,

1958, to Herbert W. Davis, assigned to Link-Belt Co., describes a method of removing cutting oil and water from metal scrap, such as chips, filings, and turnings, which are produced in machining operations.

In Figure 10, the reference character 6 designates a horizontally arranged rotatable dryer. This dryer 6 has positioned within its outer cylindrical housing an internal material supporting shell formed of a number of tangentially arranged, longitudinally extending louvers between which the drying gases pass for delivery to the bottom of the bed of material advancing longitudinally through the dryer.

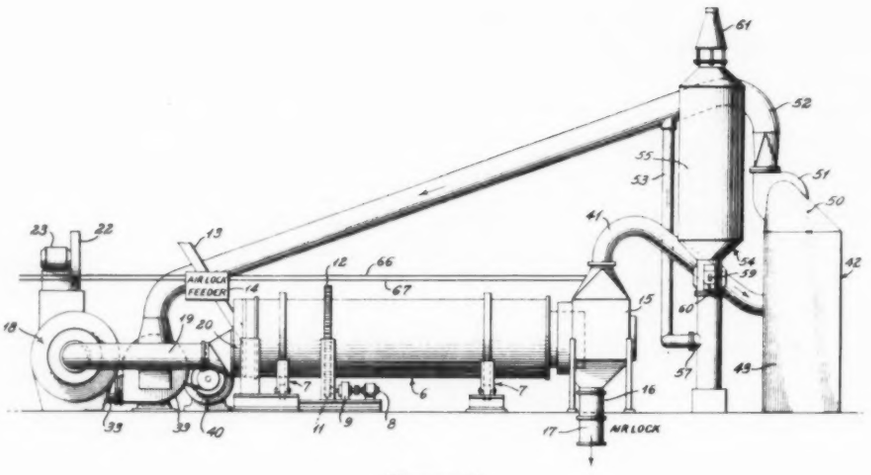

Figure 10

The dryer housing is supported for rotation about a horizontal axis by trunnions 7 and is driven by a motor 8 through a speed reducing unit 9 which drives the pinion gear 11 that is in engagement with the ring gear 12 extending around the dryer. The material to be dried is introduced into the dryer 6 through a feed chute 13 at one end of the dryer and the feed chute 13 is provided with a feeding device 14 of the type which provides an air lock across the feed chute. Material is discharged from the dryer 6 at the opposite end into the exhaust hood 15 where it drops downwardly through the discharge chute 16. The discharge chute 16 also includes an air lock 17 to prevent the escape of drying gases from the exhaust hood 15 as material is discharged through the discharge chute.

The drying or treatment gases, which are a mixture of gaseous products of combustion and recycled off-gases, are fed into the dryer 6 between the outer shell of the dryer and the material supporting shell and beneath the bed of material in the dryer. The treatment gases flow into the dryer 6 from an oil or gas fired heater 18 through the duct 19 and the inlet manifold 20.

The off-gases flowing from the dryer 6, having passed through the bed of material advancing through the dryer and evaporated the cutting oil, with which the material was wetted, contain such oil in its vaporous state when they enter the exhaust hood 15. These off-gases are removed from the exhaust hood 15 through the stack 41 to a hydrostatic type precipitator unit 42. This precipitator unit 42 is formed of a box-like casing 43 containing a body of water in its bottom portion. The portion of the casing located above the level of the water is divided into an inlet chamber and an exhaust chamber by a partition. Joined to the lower edge of the partition is a passageway which is S-shaped in vertical cross section and extends entirely across the precipitator casing. The bottom end of the passageway is located below the level of the water and communicates with the inlet chamber while the top of the passageway is located above the level of the water and opens into the exhaust chamber. During their passage through the water, some of the heavier fractions of the evaporated cutting oil, will be condensed and will settle out into the precipitator unit 42. Further, the hot off-gases will convert a certain amount of the water to steam which will be entrained by the off-gases and carried to the fan 51 and the duct 52 leading therefrom. This entrainment of steam by the off-gases serves to dilute, or reduce the percentage of oxygen in, the mixture of vaporized cutting oil and off-gases to be delivered to the heating unit 18. The duct 52 to which the mixture of off-gases and steam is delivered by the fan 51, is connected to the inlet side of the fan 39 for the heating unit 18.

Connected to the duct 52 is a bleed-off duct 53 which extends from the duct 52 to the smoke burner 54 so that a portion of the mixture of steam and off-gases will be released from the duct 52 for flow into the smoke burner.

TUMBLER BARREL FOR IMPACT CLEANING OF METAL SCRAP

△ U. S. 2,837,289, issued June 3, 1958, to Eric H. Heckett, assigned to Harsco Corp., describes an improved tumbler barrel construction as well as an improved arrangement for feeding the scrap through the tumbler barrel, whereby the cleaned material is discharged at one end of the tumbler and the waste slag particles or fines are disposed of. The invention has as its primary object the provision of apparatus of this general nature which has as its characteristics extreme ruggedness and durability and being of greatly increased capacity by reason of its large physical size and improved method for effecting the continuous flow of materials through the tumbler barrel.

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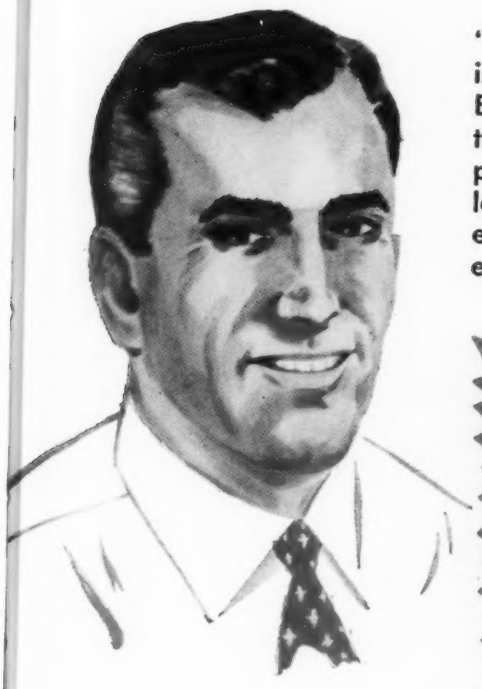

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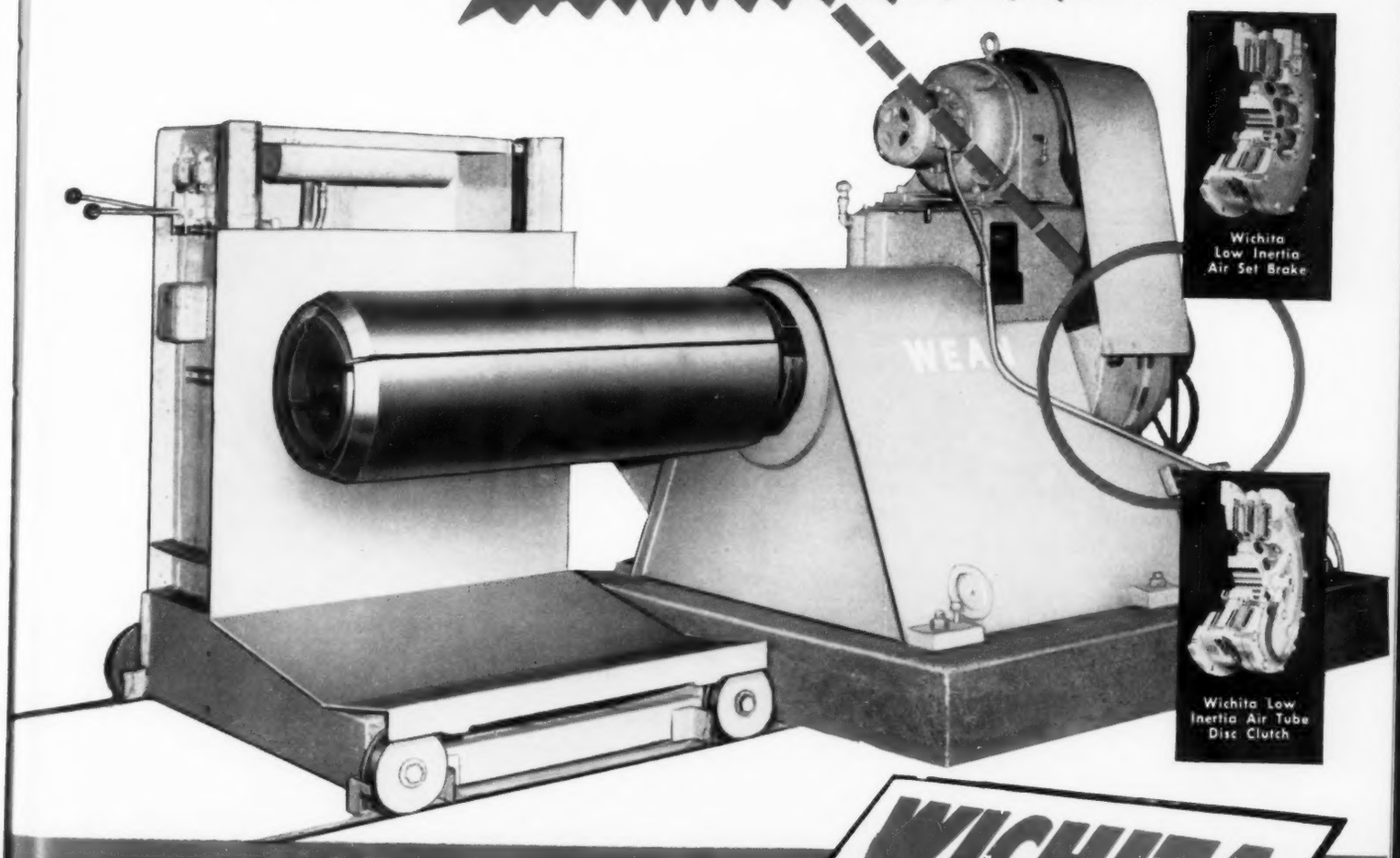

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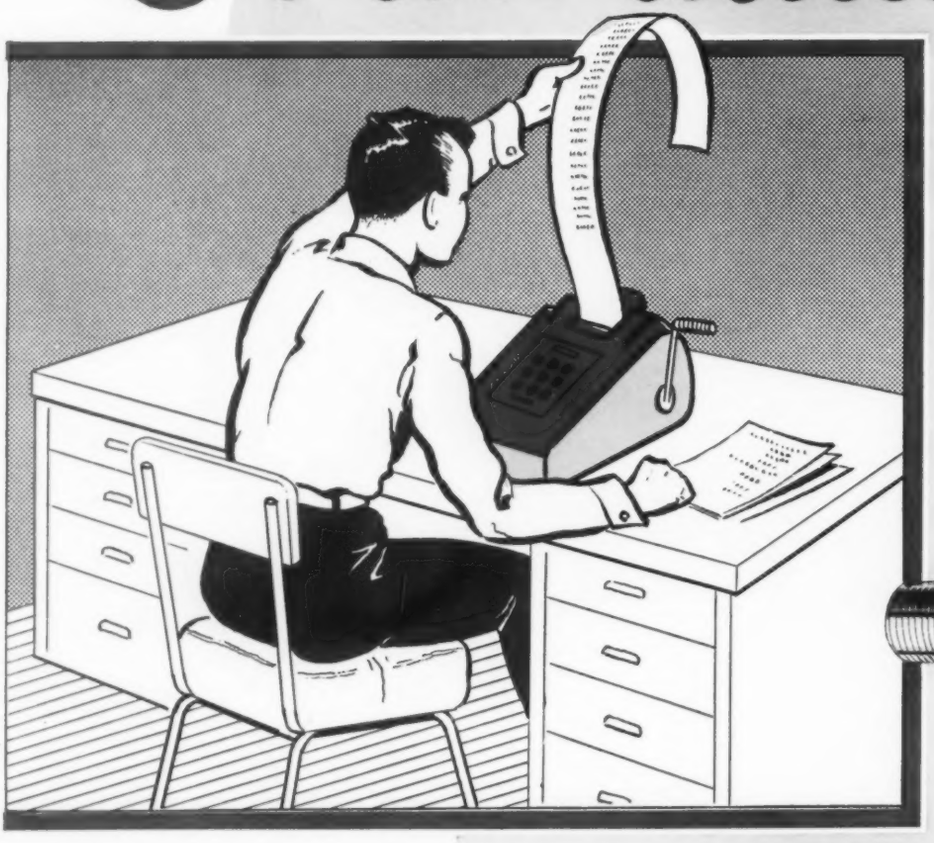

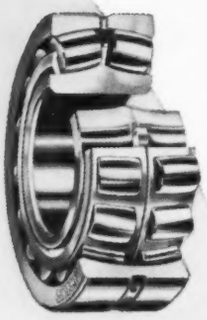

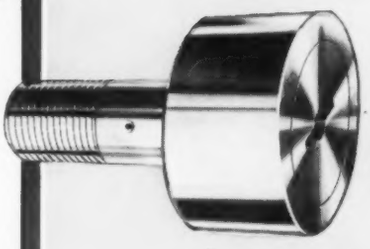

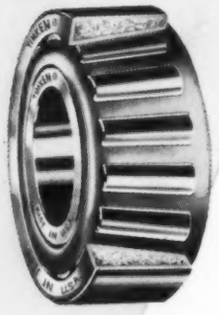

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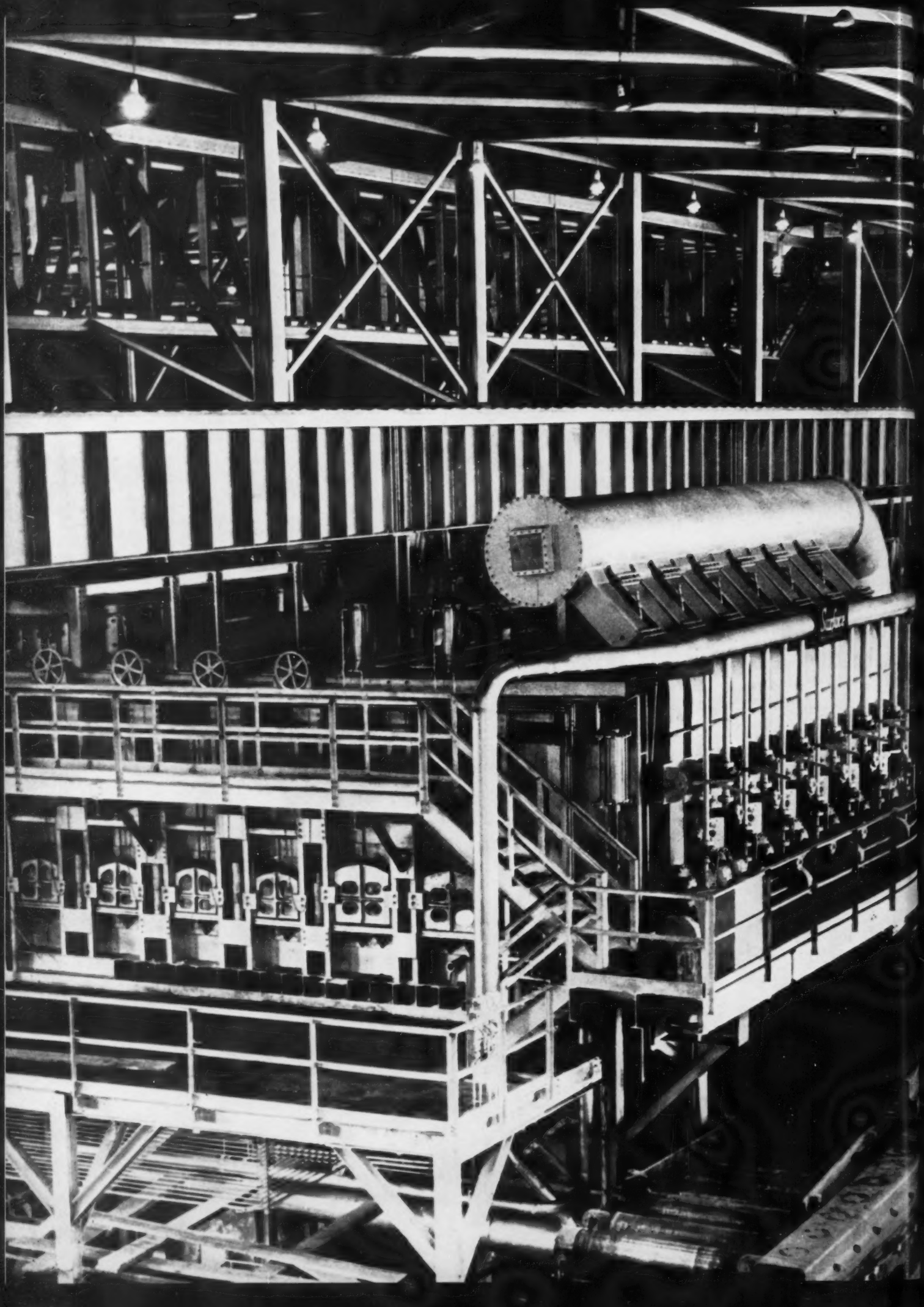

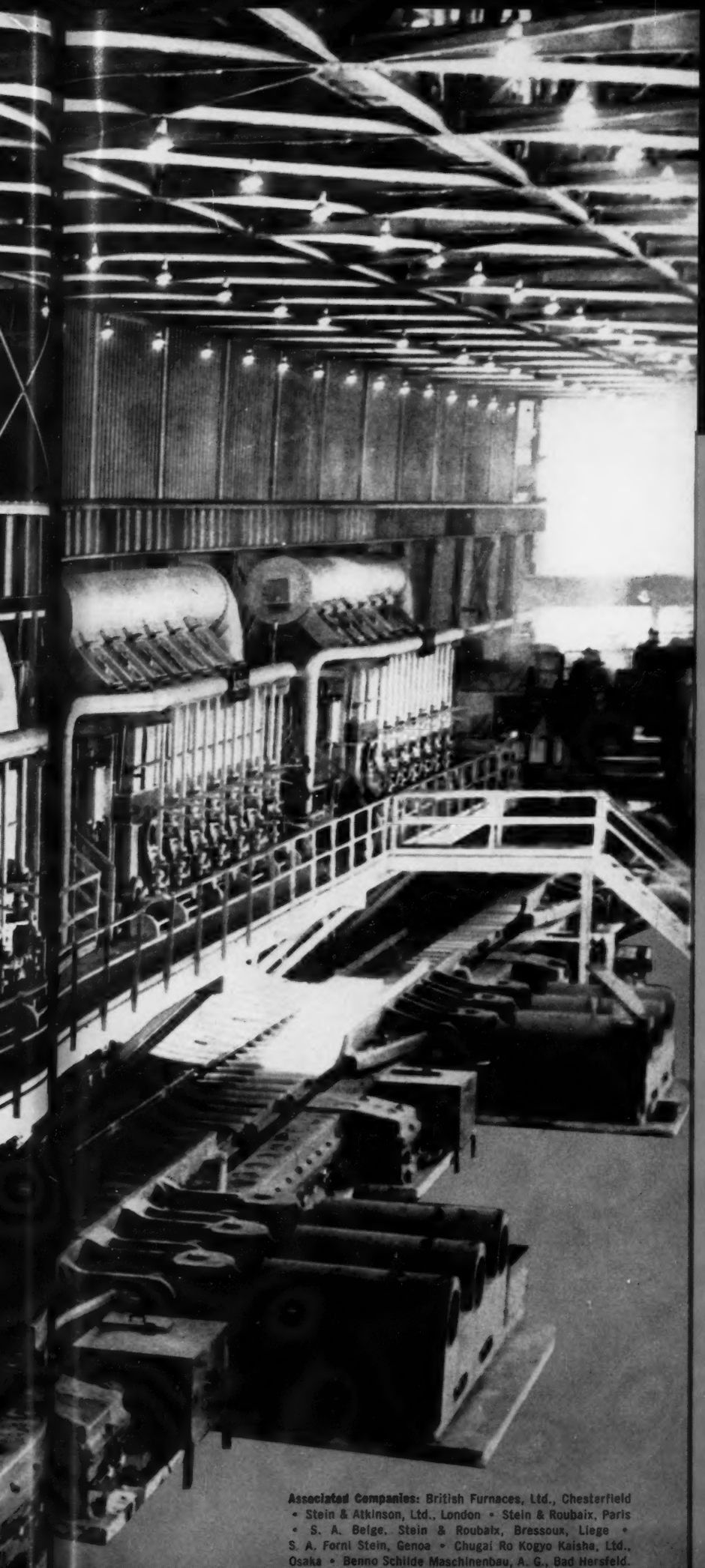

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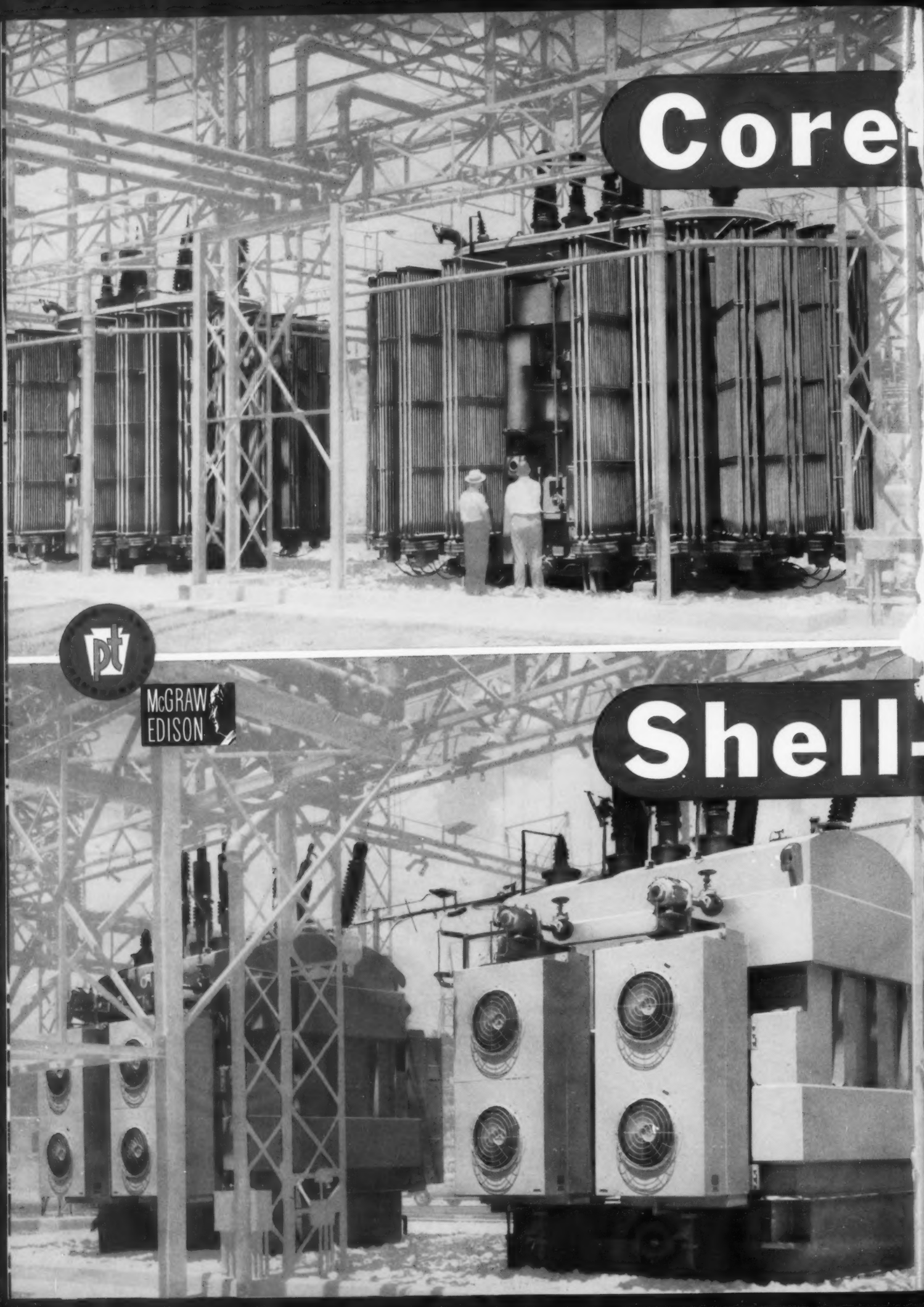
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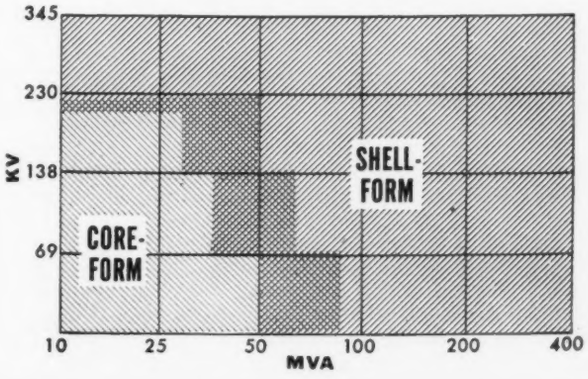

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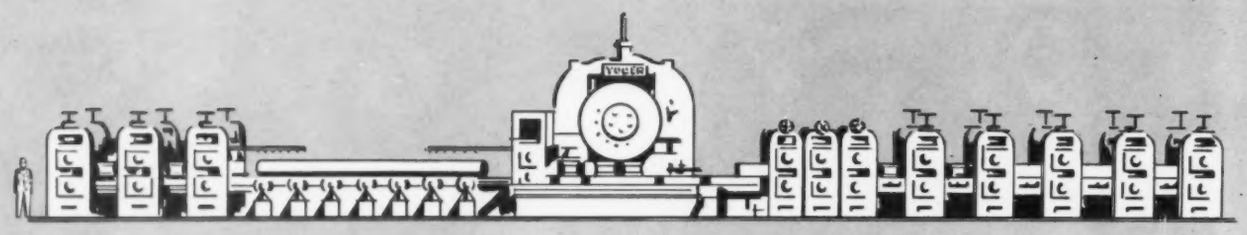

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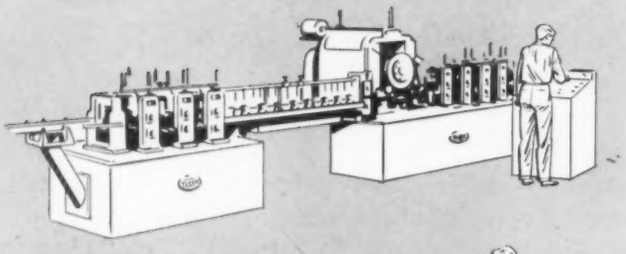

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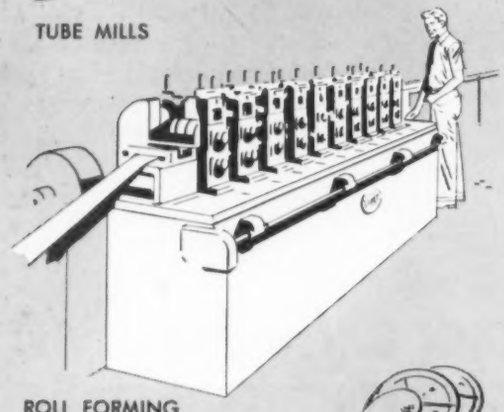

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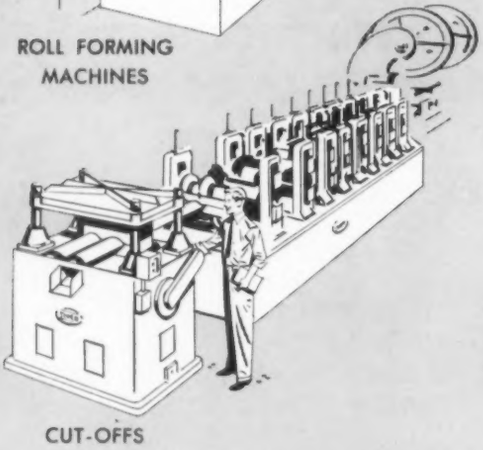

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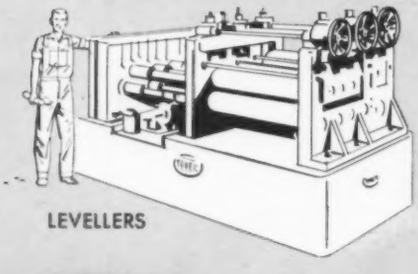

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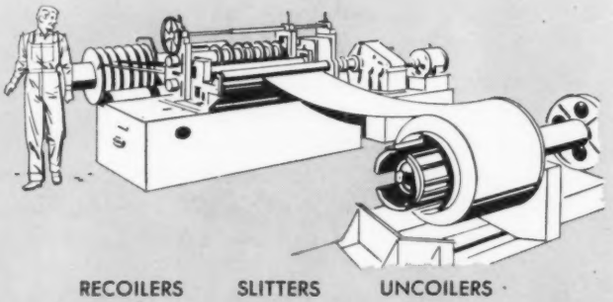

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UTILIZATION OF POWER IN ELECTRIC ARC FURNACES

By W. E. SCHWABE

Product and Process Development Laboratory

Niagara Falls, N. Y.

NATIONAL CARBON COMPANY

Division of Union Carbide Corporation

UTILIZATION OF POWER IN ELECTRIC ARC FURNACES

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This paper is an attempt to present some of the factors that influence the economics of electric steel furnace operation from the standpoint of utilization of power and power equipment.

Emphasis is put on the operation of an electric furnace with optimum currents. It is shown that optimum currents in the three phases can differ considerably because of electrical asymmetry of the furnace circuit. Furthermore, the electrical conditions for each phase change during melt-down because of changes in the arc characteristics. This requires a continuous correction of the optimum current during this period.

Because of the space limitations of this publication we have skimmed the surface of some major factors contributing to the utilization of power in electric arc furnaces. It is fully recognized that a certain amount of additional information is desirable and if this article arouses sufficient interest, we will provide a treatise on this subject at a future date.

Introduction

The electric arc furnace has established itself as one of the most effective production tools in the steel industry during the past 50 years. Highest concentration of heat combined with quick regulation, utilization of energy at efficiency levels unknown in other steel making processes, contamination-free melting and refining, flexibility, as well as easy starting and shutdown, are a few of the many reasons for its universal adoption in the steel making trade.

The most remarkable trend over the years has been the call for larger and larger furnaces requiring parallel efforts on the part of the suppliers of electrical equipment and electrodes.

From an engineering point of view, design and development of electric arc furnaces require a unique cooperative effort of metallurgical, mechanical, and electrical engineering, including application of heat transfer physics, refractory, and electrode technology. The trial and error methods of the early days have gradually vanished and have made room for application of scientific and engineering principles both in design and operation of electric arc furnaces.

It is the purpose of this discussion to review some of the pertinent problems of electric steel furnace operation partly in the light of recent research and development work. Special emphasis is put on the problem of utilization of power in existing installations which is not only of importance in view of lower power cost per ton of product, but also in higher melting rates.

Principles of Power Utilization

Melt-down – It should be stressed that it is, in practical operation, often difficult to measure the exact amount of energy consumed for melting, because the cut-off period between melt-down and refining is a variable.

Theoretically, approximately 330 KW hours are needed to melt one ton of cold scrap (270 KW hours to bring it to its melting temperature and roughly 60 KW hours to liquefy the metal). If the melted scrap is to be superheated, an additional 8 to 12 KW hours per 100°F are theoretically necessary.

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In practice, energy consumption figures are higher due to heat losses of the furnace and power losses in the electrical equipment.

Theoretical figures, in comparison with the ones obtained in practice, provide a yardstick for the degree of utilization of electrical energy in the furnace. However, they should be looked at with caution when the electrothermic heat input is augmented by exothermic reactions such as from the use of oxygen or heat present in the form of charged hot metal.

Examples are shown in Table I of actual and theoretical energy consumption for melting one ton of cold scrap in small, medium and large furnaces.

TABLE I

Furnace	Small	Medium	Large
Theoretical energy per ton.....	330	330	330 KW hrs. per ton
Actual consumption	475	440	400
Melting efficiency of furnace...	70%	75%	82.5%

Refining—It is obvious that an energy efficiency criterion cannot be applied to the refining period because the energy to be supplied during refining merely serves the purpose of balancing the heat losses of the furnace. The power required for this phase is only one-third to one-fifth of the power required for melt-down.

Factors Influencing Heat Economy – Conduction, convection and radiation are the primary factors contributing to furnace heat losses. The condition of the refractory largely determines the extent of these losses. Newer refractories in good condition tend to conserve heat, worn refractories toward the end of a cycle tend to promote heat loss. Other important contributing factors are open doors, roof ports, etc.

Table II shows the relative increase of total heat losses of the furnace during the refractory life of one roof cycle.

TABLE II

Heat Losses	
New roof — new lining	1.00
After 1/3 roof life	1.05-1.10
After 2/3 roof life	1.10-1.20
At end of roof life	1.30-1.50

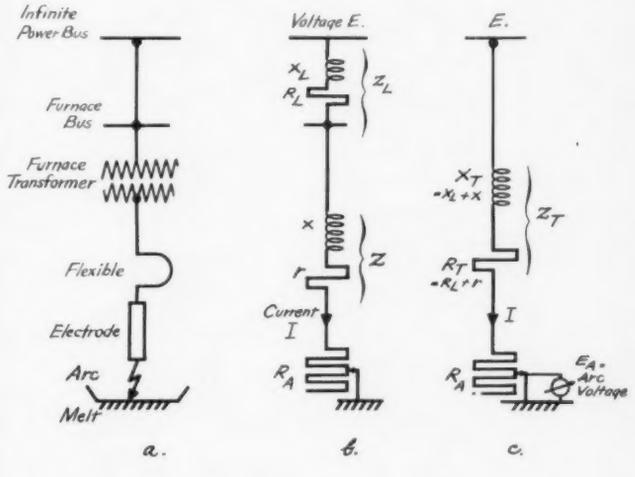
The following basic conclusion can be postulated:

During MELT-DOWN the heat input should be as high as possible in order to increase the melting rate. Time is an important element since every minute of "power-off" intervals lowers the melting rate. Power should be regulated in accordance with principles to be discussed later.

During the REFINING period the time factor exclusively dictates effective operation. Waiting periods should be minimized and reaction and slag work accelerated.

Fundamental Arc Furnace Circuit – The enormous concentration of power in the arc requires a stabilizing element in the circuit. In other words, the current from a power source before it reaches the electrode tip where the arc is initiated, must pass through an impedance. Without an impedance the arc current would "run away" and would increase to an infinitely high value which no power source or conductor would be able to sustain. Therefore, this series or "ballast" impedance acts to limit the arc current. In large furnace installations the ballast is delivered by the inherent combined impedance of the transformer, bus work, flexibles and electrode arms. In small furnace installations supplemental reactors are added on the high voltage side of the furnace transformer.

Figure 1-a illustrates a basic circuit diagram of one phase of the furnace circuit. The equivalent circuit diagram is shown in **Figure 1-b** and a concentrated version in **Figure 1-c.** In this circuit the arc resistance R_A is a variable and is controlled by positioning the electrode relative to the melt. It can be zero when the electrode contacts the melt, or it can reach infinity when the arc is extinguished. Consequently, the current may be high (short circuit) or zero (open circuit). The arc voltage spans the range from the full transformed line voltage (open circuit) to zero (short circuit).



Fundamental Arc Furnace Circuitry and equivalent Circuit Diagrams

FIGURE 1

Fundamental Electrical Characteristics—It is difficult to arrive at maximum arc power by way of metering arc voltage and current because the arc voltage, that is the potential difference between electrode tip and melt, is not readily accessible except for short time probe measurements. Furthermore, certain physical peculiarities of the arc voltage must be considered for this purpose. There is, however, an indirect approach to the problem which can be readily understood by means of a graph representing all the electrical data involved. This is shown schematically in **Figure 2.** This diagram refers to a constant input voltage E_o (represented by the infinite bus voltage or for practical purposes the plant bus voltage). The arc current at a given voltage tap on the transformer serves as X-axis. By raising or lowering the electrodes, it can be varied from zero (arc extinguished) to its short circuit value. Over this range the arc voltage varies from its initial value of the open circuit voltage at no arc current to zero when the arc is shorted out. The coordinates of this diagram are purposely layed out as percentages so that it can serve as a guide for any specific furnace.

A wattmeter connected at the primary where the voltage remains constant over the range of arc currents would measure the total power input to the furnace and give readings with a distinct maximum as shown in curve N_B. A power factor meter would show the curve PF, and a VAR meter the curve N_B. Total power (N), power factor (PF) and reactive power (N_B) are interrelated with each other and the current. One cannot be changed without influencing the other. These relationships hold true for any furnace if the primary voltage is constant.

Optimum Current — *The maximum of the useful power in the arcs occurs at a current which is considerably smaller than the current that gives maximum circuit power.*

This fact is sometimes overlooked in furnace practice, and the electrode regulators are erroneously set for maximum circuit watts instead of for maximum useful watts. This definitely constitutes a waste of energy, because the useful power at that point is lowered against optimum conditions. In the case of a furnace with a short circuit power factor of 25%, the useful power in the arcs would be only 74% when the total power input is 100%. The corresponding optimum condition would be 77.5% useful power at 96.8% total input. In other words, by not using optimum conditions the heat input is reduced by 3.5% with increase of the power consumption by 3.2%.

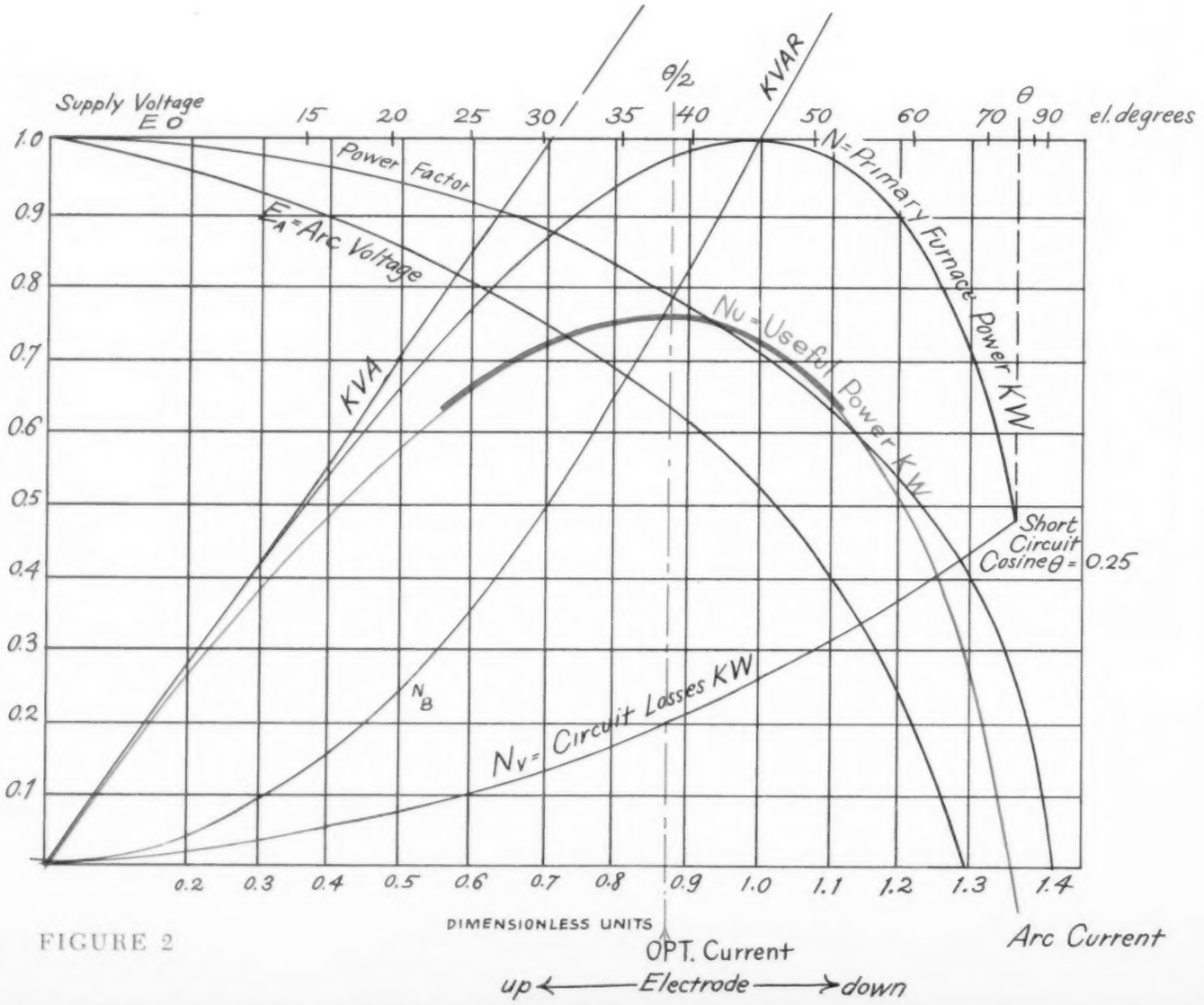


FIGURE 2

While the reactance X of the circuit does not consume kilowatts, the resistance of conductors, flexibles, and electrodes is heated by I^2r heat. The rate of lost power along the path of the current is a function of length and cross-section, which vary considerably from furnace to furnace. A very convenient common denominator is the ratio between the circuit (loss) resistance r and the circuit impedance Z (exclusive of the arc). This ratio r/Z is the cosine θ or the power factor when the arc is shorted by lowering the electrodes in the melt. (Short circuit power factor.) For medium and large size furnaces this short circuit power factor ranges from 15 to 30%, 25% being a good average. (The short circuit current lags the voltage in this case by approximately 80 electrical degrees.) This angle θ and its corresponding power factor (or cosine) give a valuable hint as to optimum current operation: it can be shown that the phase angle ø at optimum current should be one half of this short circuit phase angle θ, for example, $80/_2 = 40$ electrical degrees. The optimum power factor ($=$ cos ø) in this case would be approximately 76 p.c. The curve for the useful arc power and the corresponding optimum current for this condition ($\cos \theta = 0.25$) are also shown in **Figure 2.**

Application of Optimum Current Principle for Three Phase Furnaces – The principle of optimum current holds true for any arc in single or multi-phase systems as long as each arc circuit is considered separately.

Electric steel furnaces use three phase power, and the three circuits exercise a certain influence upon each other.

There would be no need for this part of our discussion, if there were a perfect electrical symmetry in the furnace circuit; in that case each phase would show the same behavior, and optimum conditions would be identical in all phases. In conventional furnace design these requirements are not fulfilled because:

1) The current path of the outer phases is normally longer than that of the center phase because the center phase electrode is closer to the transformer. Consequently, resistance and self-inductance in the outer phases are somewhat larger than that of the center phase. (In some cases the electrode spacing triangle is reversed, and B phase is longer.)
2) The effective resistance especially in the flexibles depends to a certain degree on the current distribution in the individual flexible cables influenced by magnetic fields and temperature non-uniformities.
3) Similarly, the self-inductance of each path depends on the geometry of the conductors, and on proximity effects of adjacent steel structures.
4) The most important contributor to electrical non-symmetry, however, is the effect of mutual inductance between the conductors.

Mutual Inductance Between Conductors – Mutual inductance is influenced by the geometrical arrangement of the conductors.

In an arc furnace of conventional design the three high current conductors are arranged side by side with equal spacing "a" **(Figure 3)** so that their geometrical centers C_1, C_2, C_3 are in one plane P.

It is obvious that the mutual inductance between No. 1 and No. 2 or No. 2 and No. 3 is larger than between No. 1 and No. 3. In other words, there is a difference in electro magnetic coupling between the three phases. One fundamental law governing coupled circuits states that the circuit whose current leads by less than 180 electrical degrees transmits some energy upon the circuit whose current lags. (If coupling conditions were identical between the three phases, the transmitted energies would be equal in all three phases; phase 1 would transmit to phase 2, phase 2 to phase 3, and phase 3 to phase 1 and the net effect would be zero).

In this case of electrical non-symmetry, however, the difference of mutual inductance between No. 2 vs. No. 1 phase and No. 3 vs. No. 1 phase induces a voltage in No. 1 phase in opposition to the current in No. 1 phase. This counter emf acts so as to increase the effective resistance of phase No. 1 conductor. Conversely, phase No. 3 conductor receives an induced voltage which is in phase with No. 3 phase current, and its effect is a decrease of effective resistance in this conductor. Phase No. 2 (center phase) is not affected by this phenomenon.

For these reasons, phase No. 1 delivers less power and is called the "cold" or "dead" phase. Phase No. 3, called the "hot" or "wild" phase, delivers more power; however, the center phase power is still larger than No. 3 phase because of lower self inductance and resistance. The sum of the optimum power in all phases under these conditions is identical with the sum that could be obtained at perfect electrical symmetry, however, the uniformity of heat distribution in the furnace is somewhat disturbed.

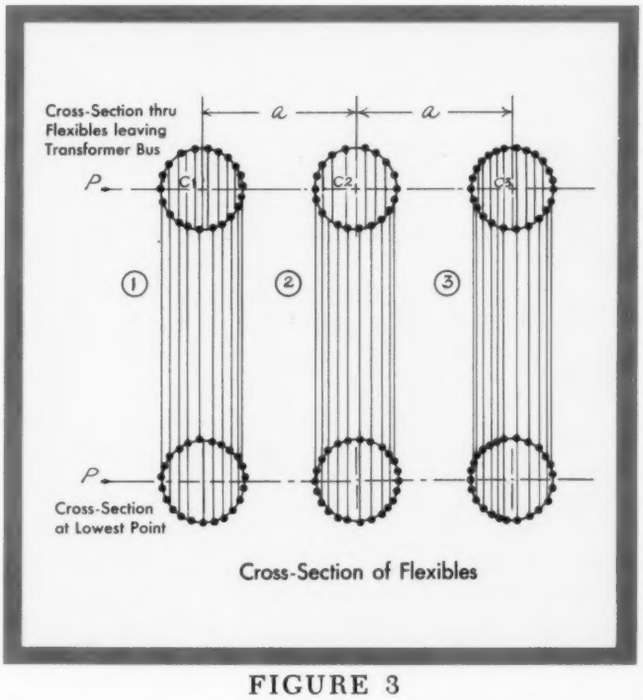
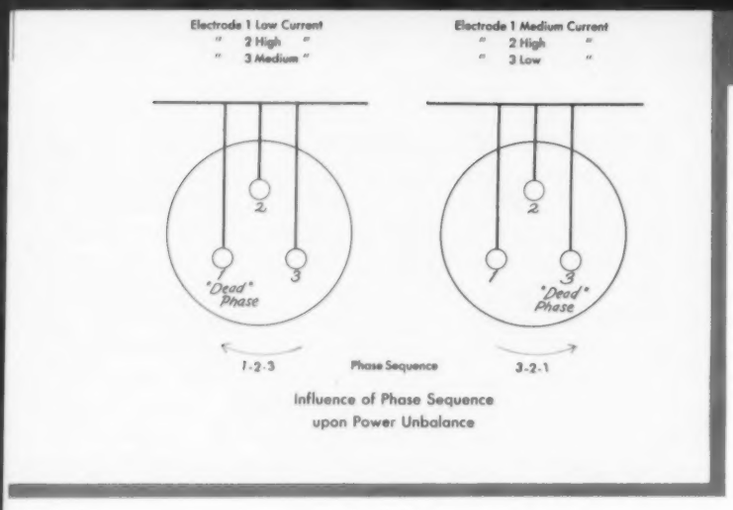


FIGURE 3

Importance of Phase Sequence – During investigations in the field, it was found on several occasions that the



Influence of Phase Sequence upon Power Unbalance

FIGURE 4

current settings, although approximately adequate in their magnitude, did not correspond to the phase sequence and consequently the melting rate was too low and the power consumption too high.

In the preceding section on mutual inductance, it was assumed that we have electrical phase sequence 1-2-3 or A-B-C. The principle of optimum current in each phase dictates that the individual arc resistance should be made equal to the sum of all series impedances in that phase exclusive of the arc. This requires a higher optimum impedance and consequently lower optimum current in phase No. 1; and a lower optimum impedance and higher optimum current in phase No. 3. These conditions are reversed if the electrical phase sequence is 3-2-1 with the center phase not being affected; phase 3 would be underpowered (dead phase) and phase 1 would be the "hot" phase. See **Figure 4.**

Improving Electrical Balance of Circuits – Electrical balance leads to uniform heat generation, reducing of hot spots in the refractory, and equalized electrode consumption in the three phases. Practical considerations restrict complete balancing of phase impedances in conventional furnaces by locating flexibles and the rest of the high current conductors on the corners of an equilateral triangle. There are, however, several possibilities that can result in improvement over present conditions:

a) Flexible bundle conductors can be replaced by water cooled cables of considerably smaller overall cross-section. These can, over a part of their length at least, be arranged in a triangular pattern.

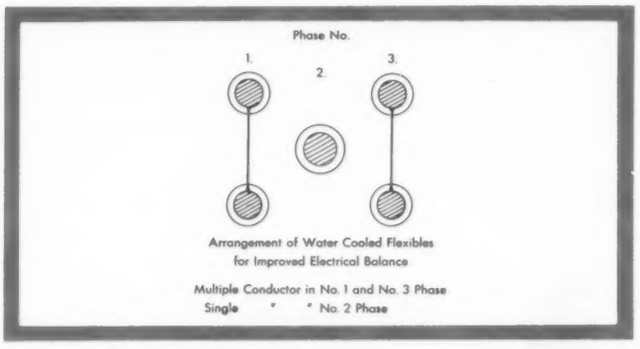
b) If the flexible bundle of the center phase only is replaced by one water cooled cable and the outer phase brought closer together, coupling between the outer phases can be improved.

c) Water cooled cables can be arranged as shown in **Figure 5.** The outer phases carry the current in two or more parallel small water cooled cables, whereas, the center phase has only one heavy water cooled cable.

d) In cases where the conductors of the high tension feeder line leading to the steel plant or to the furnace transformer are electrically unbalanced (the three conductors in one plane) the "dead" phase of the feeder should be connected to the center phase of the transformer. This tends to improve the overall balance.

e) Unequal phase voltages resulting from a furnace transformer with purposely unbalanced secondary voltages (higher voltage for the dead phase) are restricted to the rare cases where furnace transformers with a secondary Y connection are used.

f) Lengthening the center phase flexible bundle so that an equilateral triangle is obtained at the lowest point has shown improved balance.



Arrangement of Water Cooled Flexibles for Improved Electrical Balance

FIGURE 5

Influence of Harmonic Distortion of Arc Currents – Arc power is lowered by the influence of harmonic distortion. Harmonic distortion is caused by the discharge mechanism of the arc. It was found that arc currents at start of melt-down display a remarkable degree of harmonic distortion. As the average temperature of the charge increases during melt-down, the degree of distortion recedes gradually and during the latter part of melt-down, the current pattern assumes a sinusoidal shape. During the initial erratic period of melt-down, practically each half cycle of each phase current shows a different pattern.

What is the effect of harmonic distortion upon the optimum current concept? Optimum conditions, that is maximum heat generation in the arcs, exist if the external (or circuit) impedance equals arc resistance. The greater part of the circuit impedance is inductive, and is proportional to the power frequency, for example, 60 cps.

The Fourier analysis of currents showed that they contained an appreciable amount of higher harmonics which combined would be effective as an equivalent sinusoidal power frequency of up to 75 cps. Consequently, the inductive part of the series impedance increases with harmonic distortion paralleled by a minor increase of the resistance component due to a more accentuated skin effect. The increase of resistance by skin effect is, however, negligible for practical purposes.

Therefore, distorted currents increase the ballast impedance and in order to establish optimum conditions the arc resistance must be increased too. This also results in lower arc power. This presents a difficult task as far as electrode regulation is concerned.

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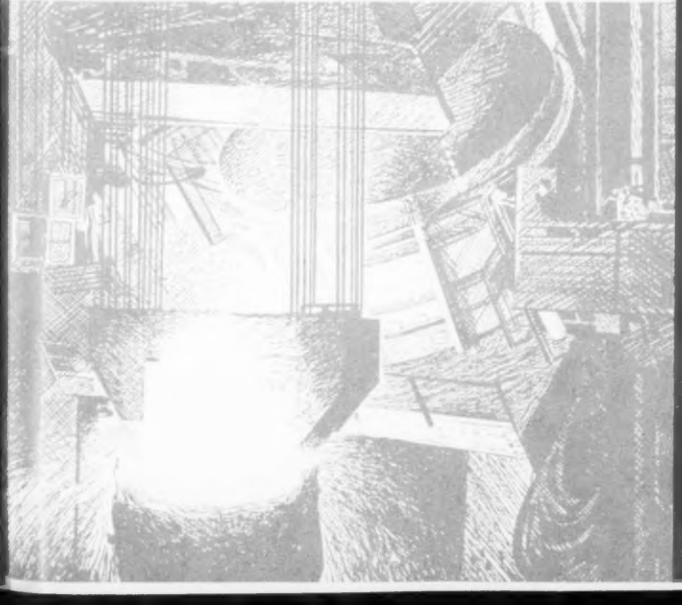


Arc Stability and Maximum Heat Generation – From the viewpoint of maximum heat input to the furnace it is important that the resistance of the arc, and consequently its length be maintained as constant as possible. There are several factors that tend to disturb an existing arc by changing its length during melting:

1) Erratic movement, essentially caused by gravity, of that part of the charge which is actively engaged in providing the foothold of the arc.
2) Turbulence of the surface of the molten pools under the arcs.
3) Arc flare caused by electromagnetic forces of the arc currents.

Modern electrode regulators are capable of correcting a disturbance by re-establishing the desired current in a short time. This holds true, especially for erratic movement. Arc regulation involves rapid raising or lowering of the electrode column without overshooting. Short-timed variations of the arc length caused by melt-turbulence and arc flare occur too fast to be fully corrected by the regulator. Each deviation from the optimum current value leads to a reduction of the useful power in the arc.

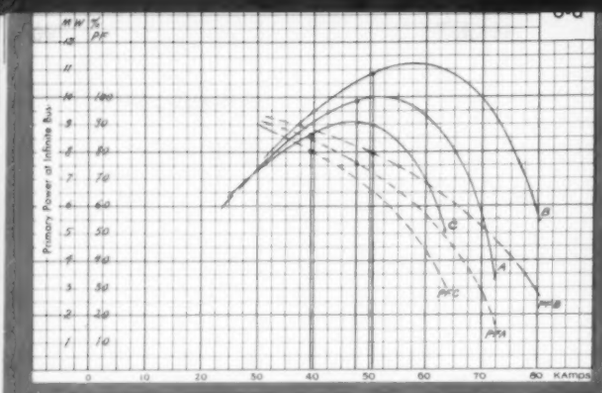
Power Characteristics of Large Furnaces

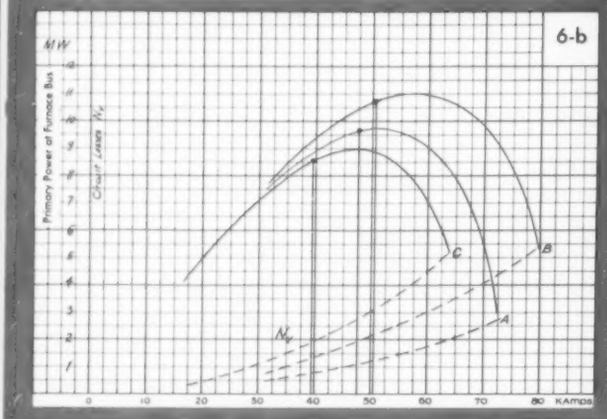
A typical practical application of the fundamentals of the power circuit and regulation of power, discussed in the preceding sections, was made on a 130-140 ton furnace using 24″ diameter graphite electrodes and a nominal high tap voltage of 465 volts between phases. The electrical phase sequence at the electrodes is C-B-A.

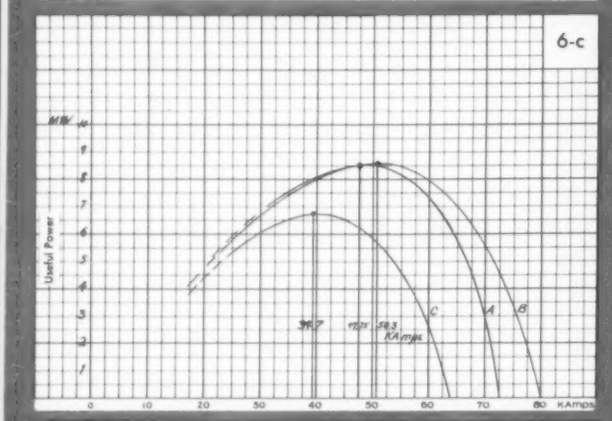
The electrical data of the furnace were determined experimentally by means of special instrumentation. At a low tap voltage the three electrodes were lowered in the melt, and readings of voltage, current, and phase angle were taken for each phase. These data yielded the values for the furnace impedance and power line impedance between the "infinite bus" and the steel plant bus.

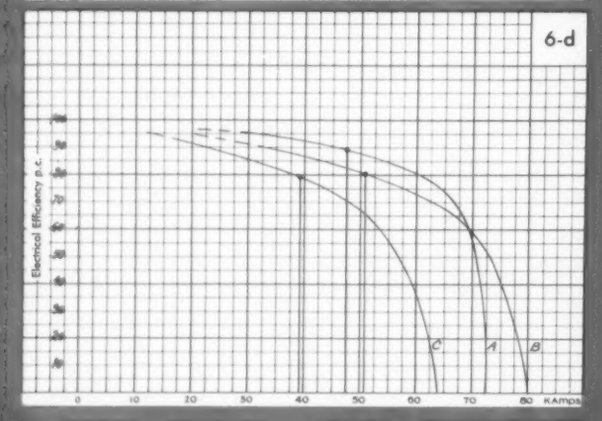
The corresponding values of the furnace impedance for the highest tap voltage were calculated. (This could not be done experimentally because the high short circuit currents would have tripped the circuit breaker almost instantaneously.)

With these values, the characteristic curves for high tap were calculated as illustrated in **Figure 6. Figure 6-c** is most interesting from the standpoint of maximum heat input to the furnace confirming the theory that the three phases have power maxima occurring at three different currents. The highest power is obtained in the center phase B, followed by a slightly lower power in A, whereas, C phase power is distinctly lower. Therefore, the currents in the three phases should be adjusted to these optimum conditions. It is quite obvious that the sum of power in all three phases would be lower, if for example, the furnace were operated with the same current in all three phases. On the other hand, if the same power in all three phases is desired, power in phase A and B would only partly be utilized, and the total power would drop considerably.









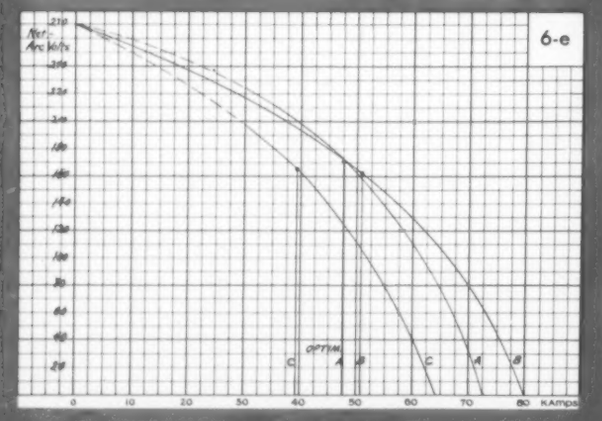


FIGURE 6

This asymmetry is also reflected in the power conditions on the primary of the furnace transformer, and at the infinite bus, as well as in the power factor.

Furthermore, it points to the fact that diagrams depicting the combined three phase power plotted against a common current have no meaning unless this current includes some definition on the degree of asymmetry in the three phases.

The electrical efficiency as defined by the ratio between useful power **(Figure 6-c)** and primary power **(Figure 6-b)** at the furnace bus, is shown in **Figure 6-d.** It is affected by electrical asymmetry, and drops off with current increasing, due to the increase of circuit losses with the square of the current.

As far as heat transfer from the arc and refractory are concerned, **Figure 6-e** reveals the influence of arc currents upon the arc voltage and arc length. The advantage of having almost identical arc voltages (= arc length), between electrode tip and melt when using optimum condition in each phase is quite obvious.

Conclusion

These scientific and engineering principles from both theoretical and practical aspects point up the fact that highest melting production rates are obtained with optimum currents. However, it should be stressed that increased efficiency of energy conversion from electricity to heat in the furnace can be achieved by using currents that are somewhat lower than optimum current. This results in lower power input and slower melting. The choice between fastest melting or increased efficiency of energy conversion depends strictly on operational factors.

Also it should be pointed out that electrodes (the final link between power station and arc) withstand extreme thermal and mechanical conditions, and perform their duty at an efficiency of 98% and above.

All of these relationships provide a utilization of power in electric furnaces which is superior to combustion type furnaces: electric steel melting requires approximately ⅓ of the BTU's needed in an open hearth furnace.

It is hoped that this presentation will stimulate interest in the many factors contributing to the utilization of power and power equipment in electric arc furnaces.

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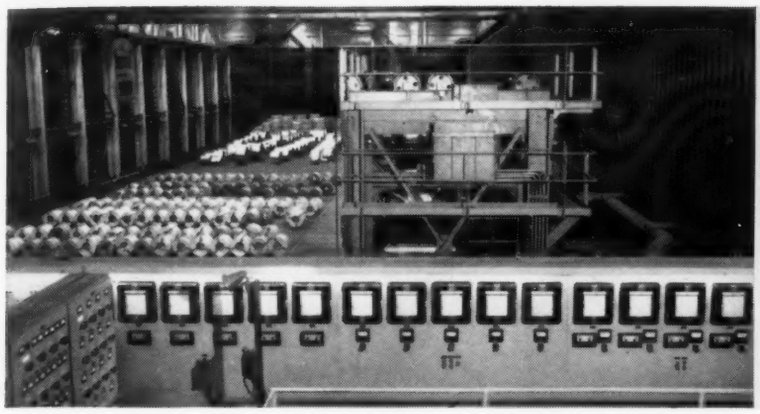

Continuous Annealing Line for tin-plate strip has a 4-section furnace precisely temperature-controlled from this panel of Speedomax G instruments. Control is applied to the 6 zones of the "heat-up" section, 5 zones of the "soak" section, and 4 zones of the "slow-cool" section. Additional recorders measure actual strip temperature and gas stack temperature.

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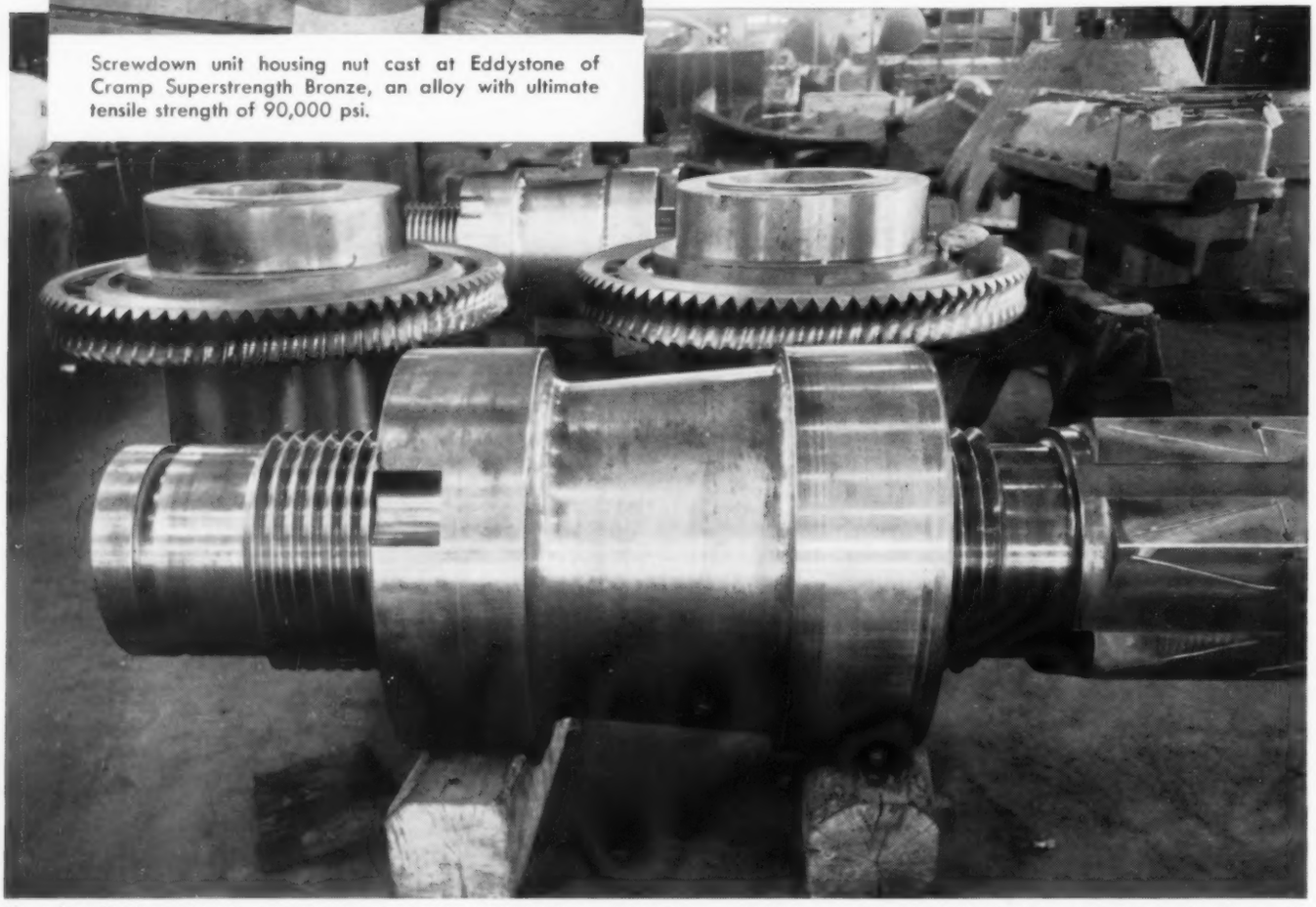

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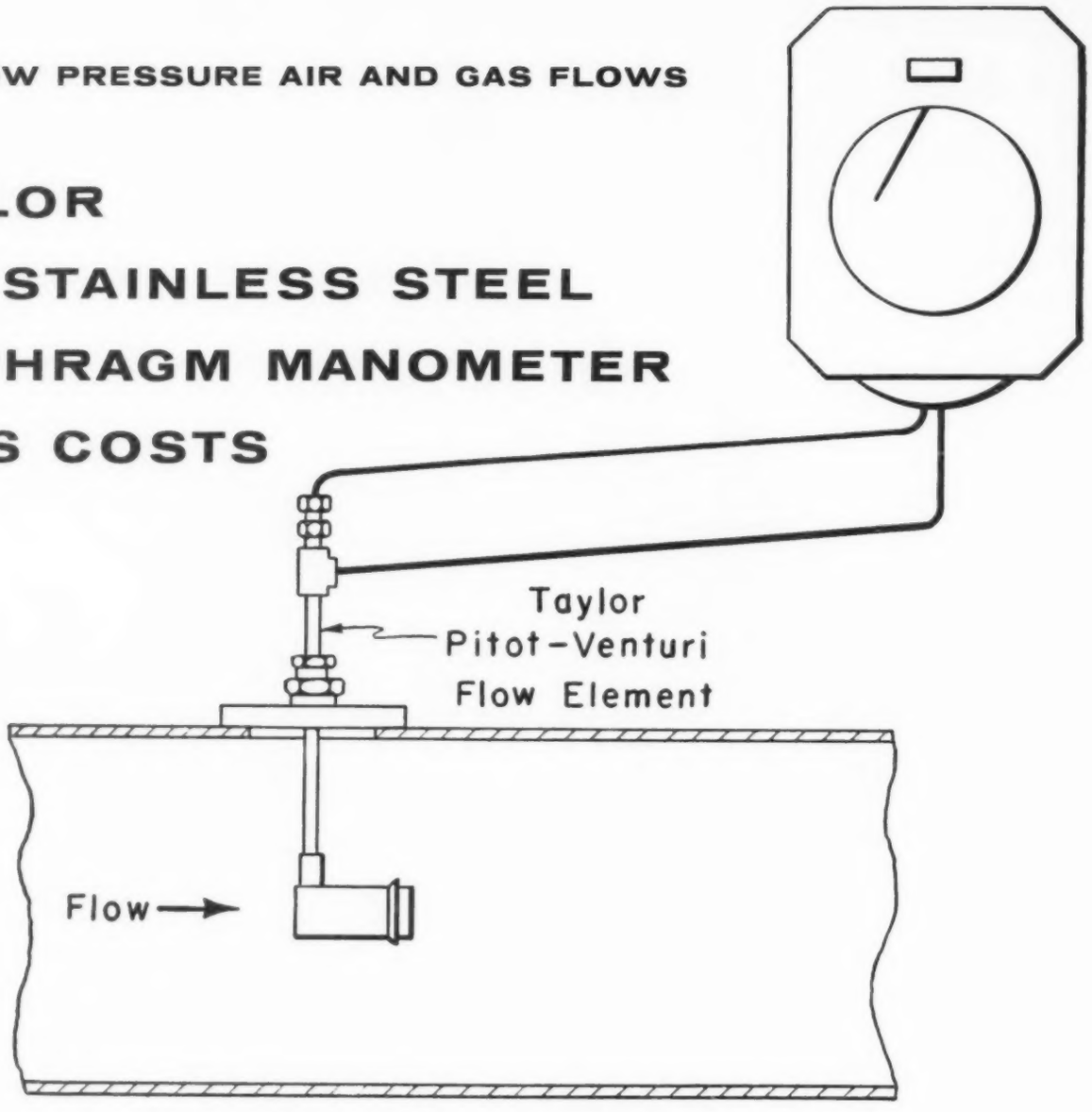

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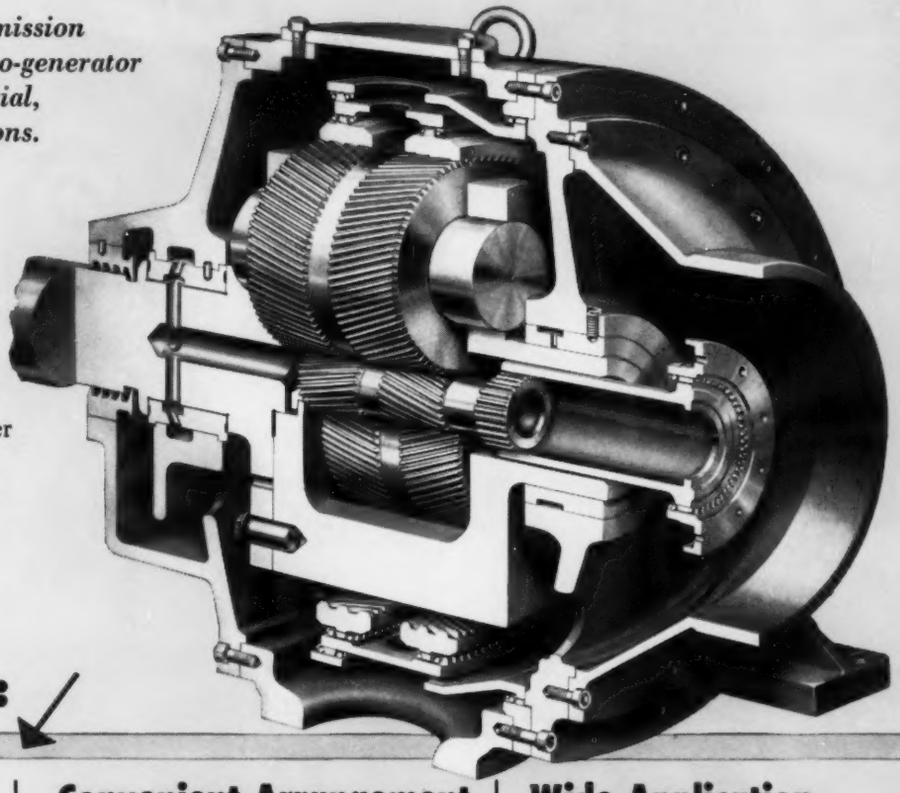

This cutaway view of the De Laval-Stoeckicht Planetary Gear shows how it provides flexibility for proper load distribution throughout the gear members. The thoroughly proved and tested design is completely reliable in transmitting high horsepower for high speed applications. • Highest efficiencies (98% or higher)... no high speed bearings... less friction losses.

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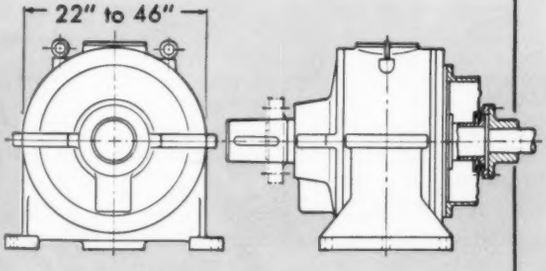

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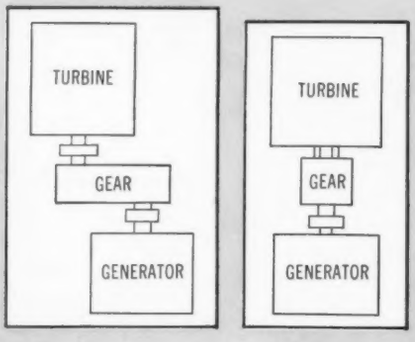
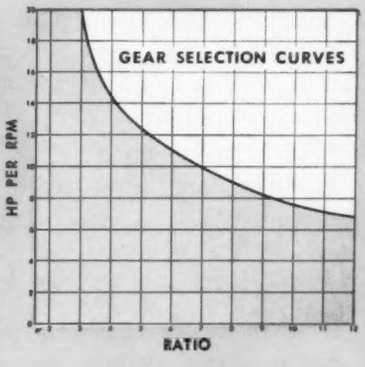


Wide Application

Capacity range shown in shaded area on chart below. For other applications, contact your De Laval Sales Engineer.



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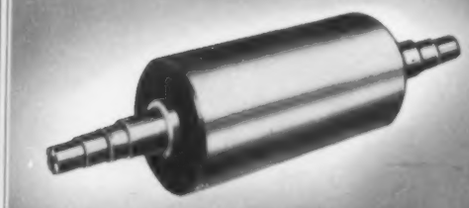

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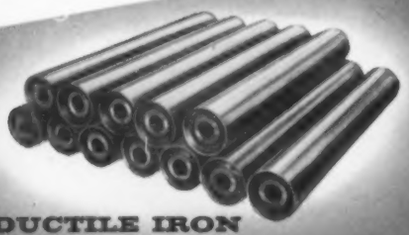

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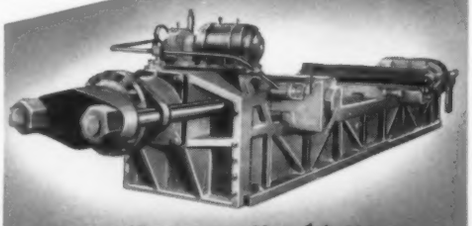

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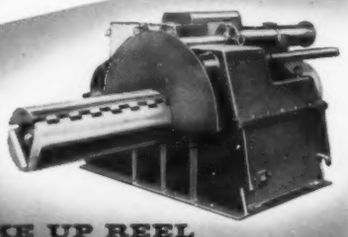

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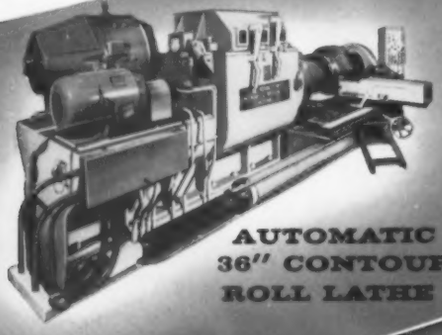

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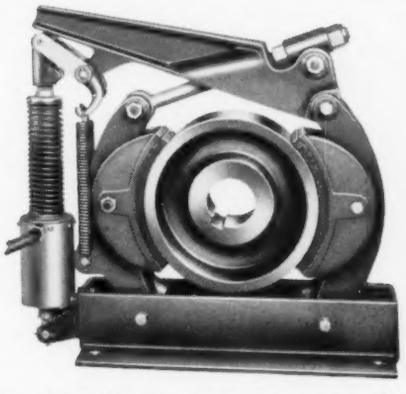

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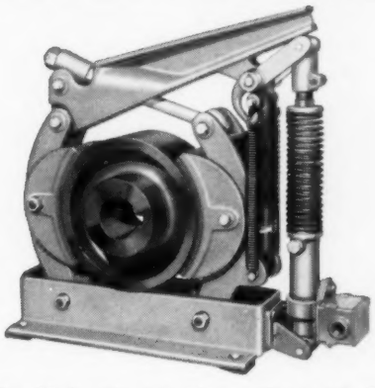

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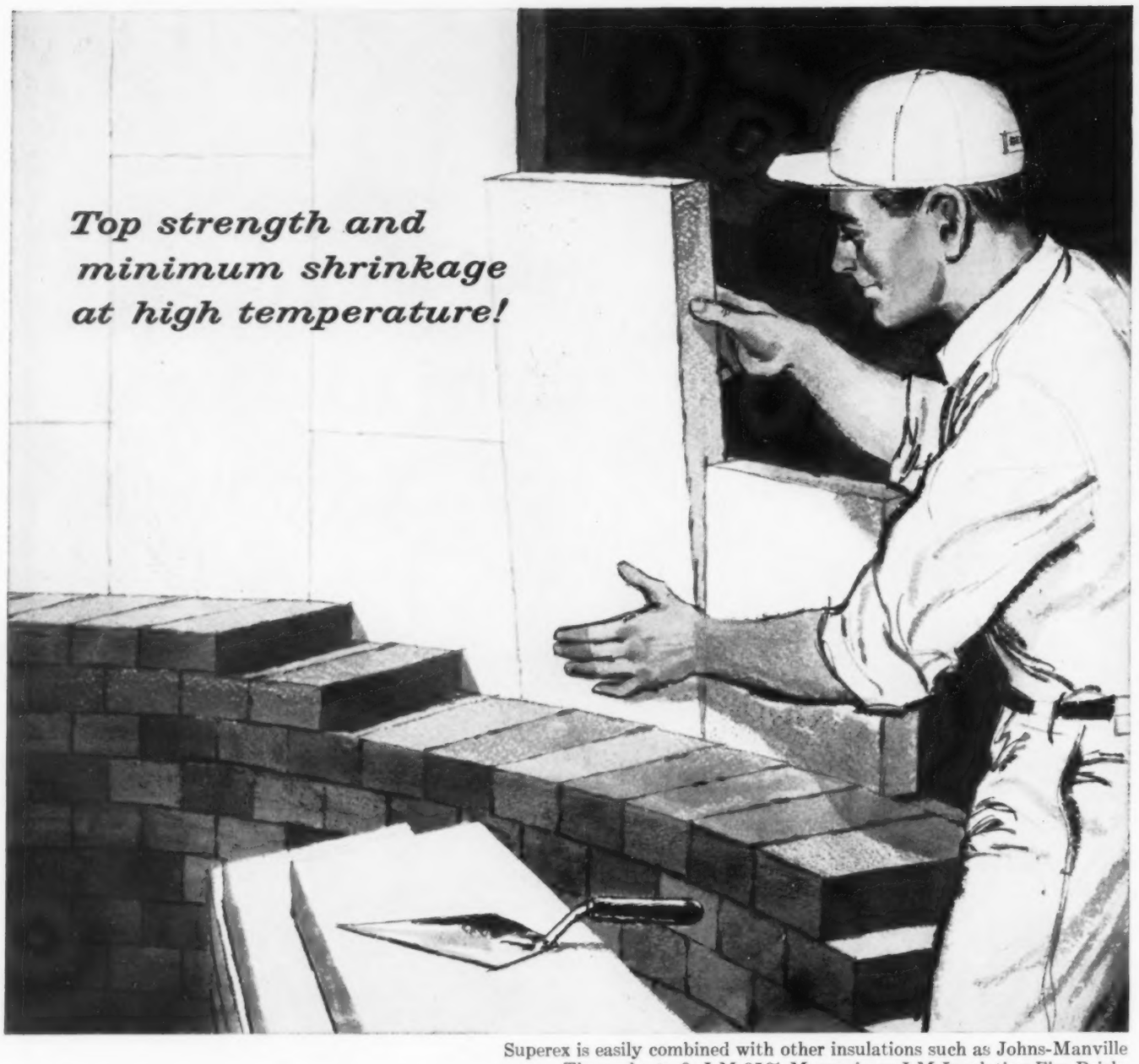

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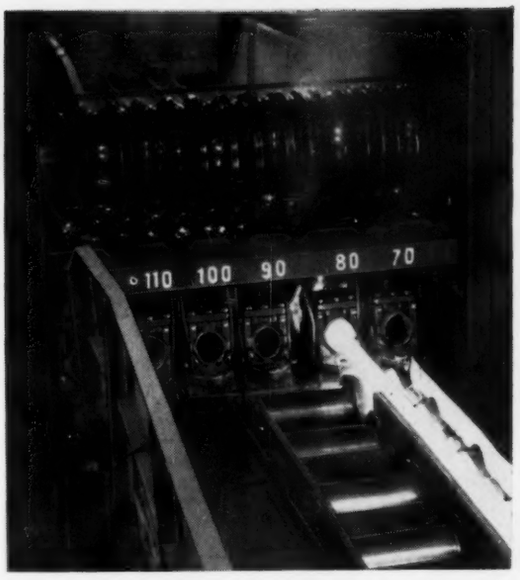

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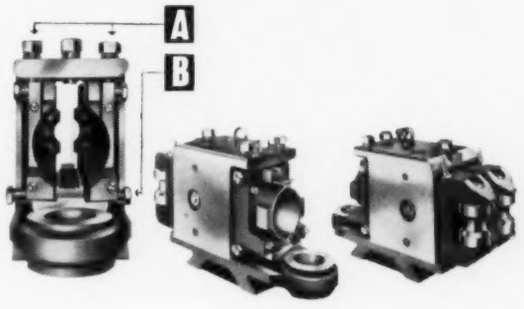
3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be thick, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.



7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

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B	3½	78,000	30	2-3	.02-.08
C	3	85,000	30-40	2-3	.01-.03
D	3	45,000	30	2	.02-.03
E	½	75,000	50	—	.02
F*	½	26,000	12	5	.10
G*	½	26,000	12	5	.10
H	½	90,000	29	—	.04

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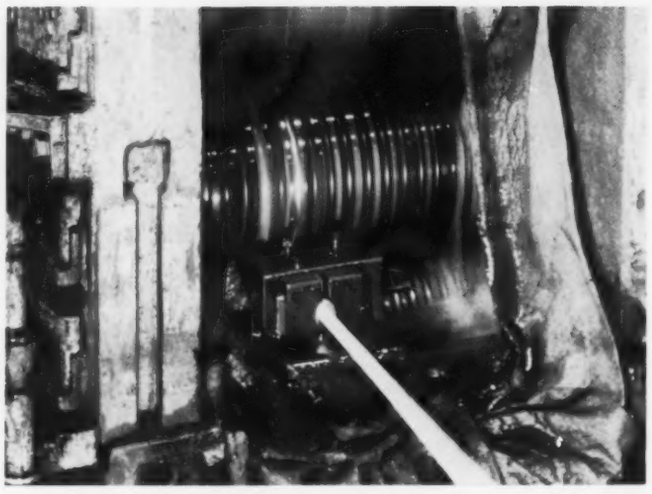

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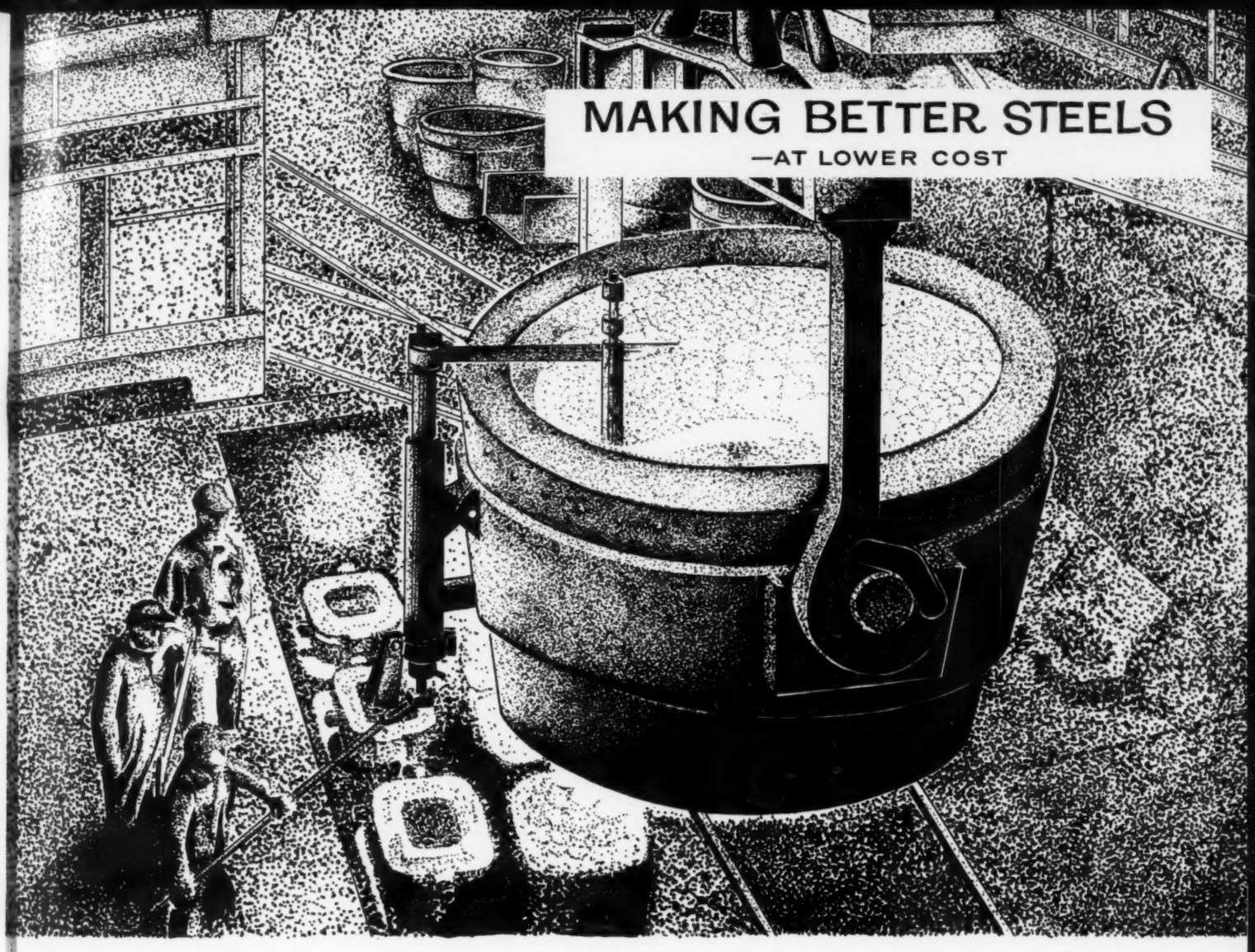

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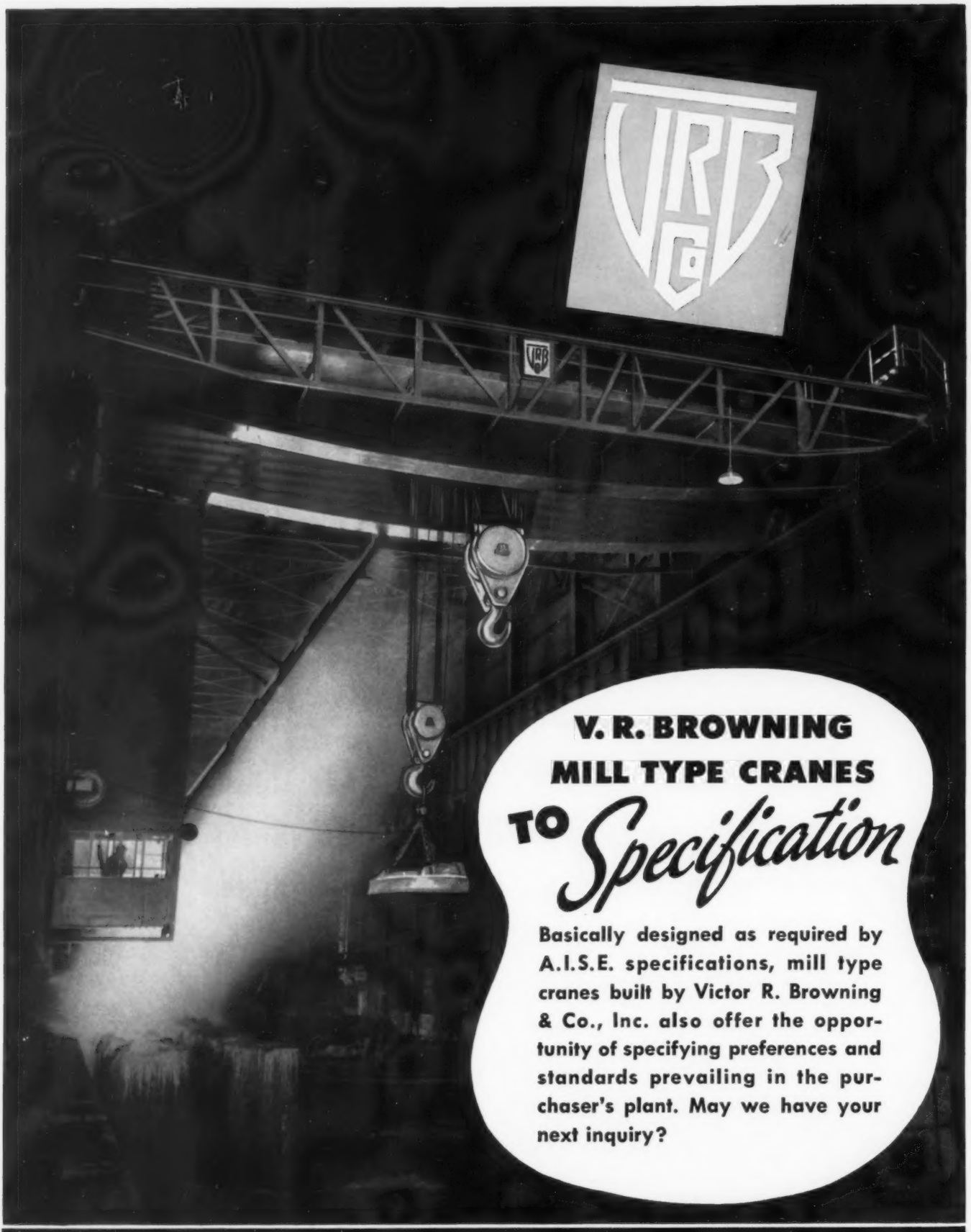
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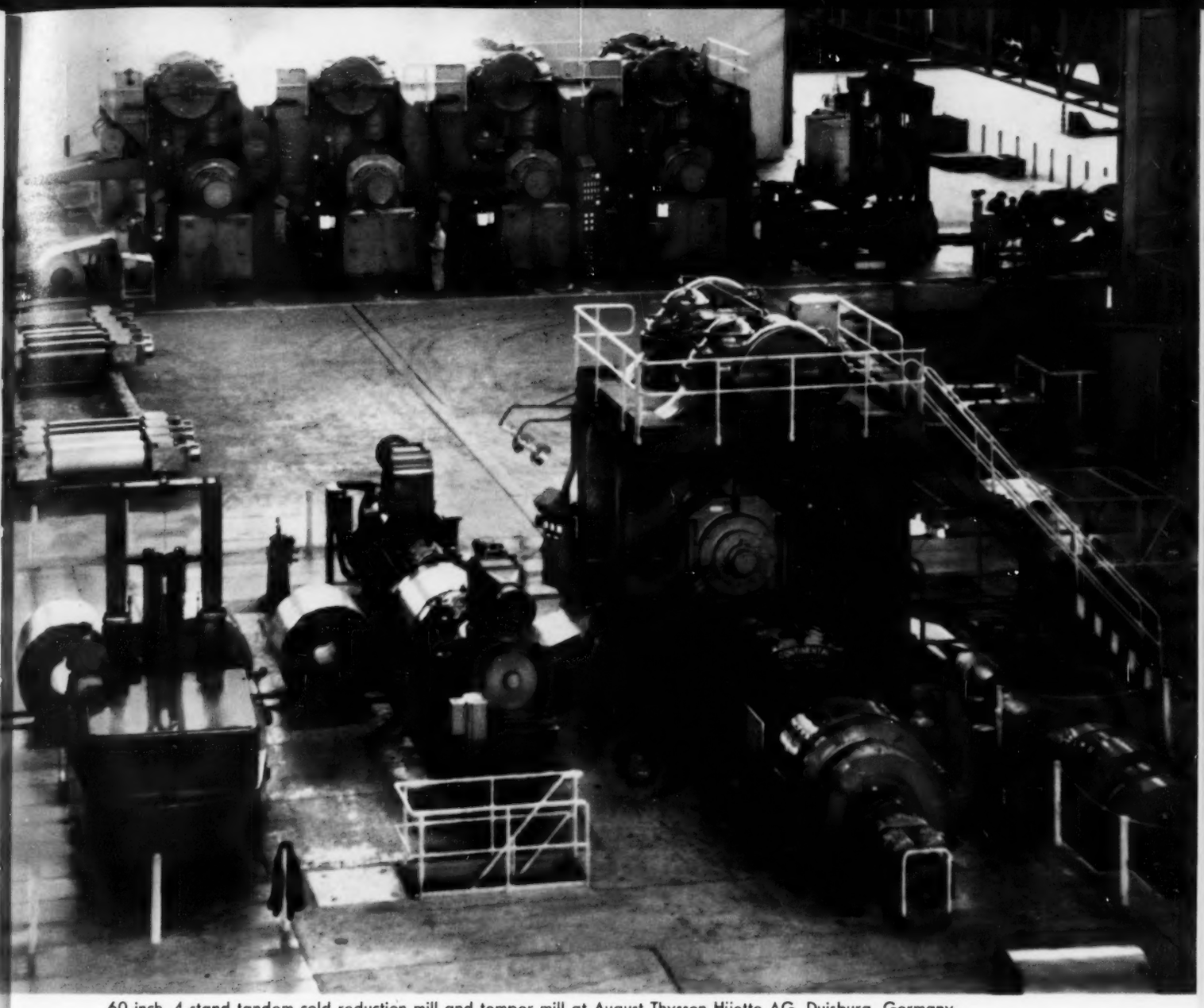

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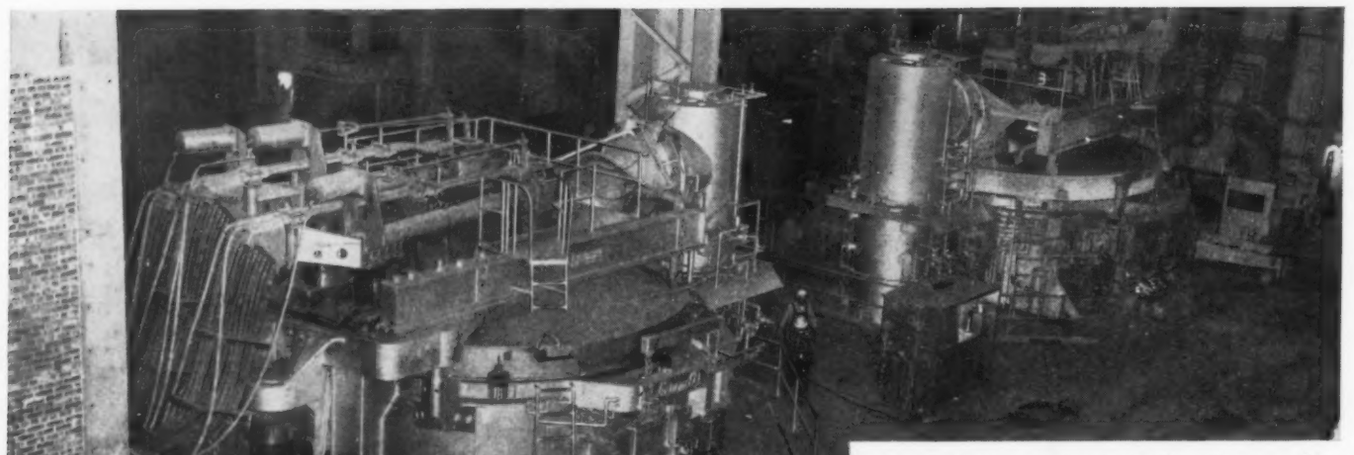

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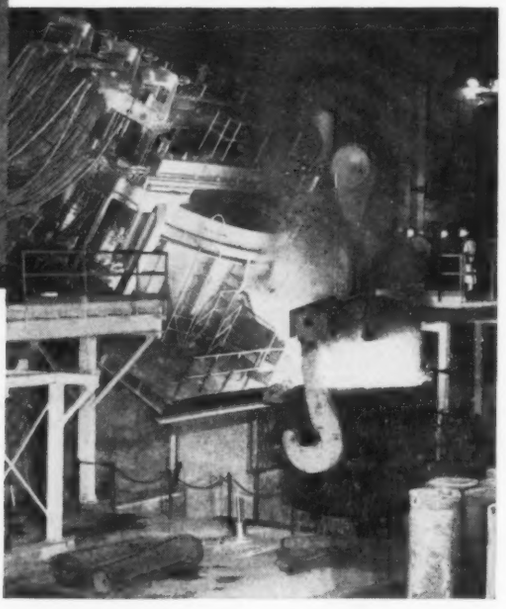

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application of
Progressive Induction Heating
to forged roll hardening operations

The progressive induction method of heat treating rolls gives better control of the hardening operation . . . . internal stresses are reduced, grain structure is improved.

by John Dugan,
Works Manager
and Chief Metallurgist,
The Ohio Steel Foundry Co.,
Lima, Ohio

DURING the past two decades, tremendous changes have been made in tandem cold mills and in reversing cold mills. During this period improved methods for rolling a wide variety of materials have been developed; greater widths are being rolled, better finishes are being supplied, and rolling practices designed to impart additional physical properties to the rolled metal have been worked out. All of these changes in rolling practice have required corresponding changes in the methods of roll manufacture, so that rolls could be supplied which would carry out the developments listed above.

While all of the operations which enter into the production of a forged cold mill roll are of extreme importance, probably the heat-treating and quenching operations are the most critical phases of forged roll manufacture. It is the primary object of this paper to show some of the effects of heat-treatment and quenching on a forged steel work roll, so that a comparison between heat-treating methods can be made. In developing this explanation of heat-treating methods, a roll 21¾ in. diam by 54 in. body length will be used for illustrative purposes. The information developed for this roll is applicable to all forged roll sizes, generally.

Figure 1 shows the type of roll covered in this discussion. Rolls of this type may be used in three- four- or five-stand tandem mills, in reversing cold mills or in temper mills.

In 1941 the Association of Iron and Steel Engineers published a comprehensive study entitled, "The Modern Strip Mill," which contains a description of cold mill work roll life. This description is included here as it serves to indicate in a general way the life expectancy of the type roll which we are considering. "Roll life in cold mills varies over a fairly wide range depending on product, etc. For sheet rolling, work rolls may give up to 3000 tons or more between dressings on No. 1 stand, 1000 tons to 11,000 tons between

Figure 1 — Roll shown is the type to which progressive induction heating can be readily applied.

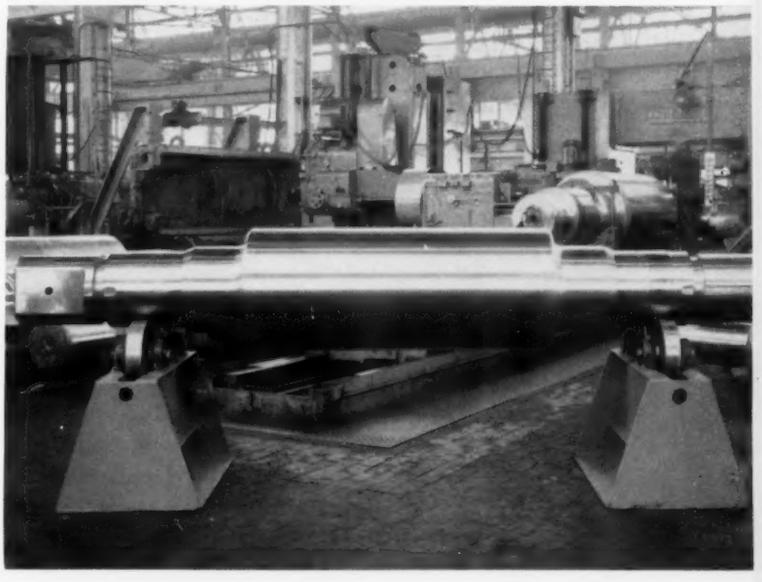


Figure 2 — Structure shown is typical of a forged roll hardened by conventional methods.

dressings on No. 2 stand and 600 to 800 tons on No. 3 stand. In tin-plate rolling, many mills change the work rolls of the last finishing stand every four hours or every 150 to 175 tons. Hardened steel rolls have a total life of ¾ to 1 in. on the diameter which may give as many as 60 dressings or perhaps a total production of 40,000 tons. If the mill permits the use of the reduced diameter rolls they may then be rehardened for a second run. Some plants use these rehardened rolls in the temper mills. A general average may be taken as 0.001 in. reduction of roll diameter per 100 tons rolled."

"Roll life in the reversing mills averages somewhat less than in the tandem mills, based on single pass tons."

"Rolling pressures which rolls of this type may be expected to withstand, range from 50,000 lb per in. of strip width up to in excess of 125,000 lb per in."

Several tables showing the amount of service life obtained from original hardened state for various sizes and types of forged rolls at the present time are contained in the conclusion of this report. These averages have been established over a very long period using rolls hardened by quenching after through heating. It can safely be assumed these figures represent the practical hardness penetration limits of the conventional through heating method.

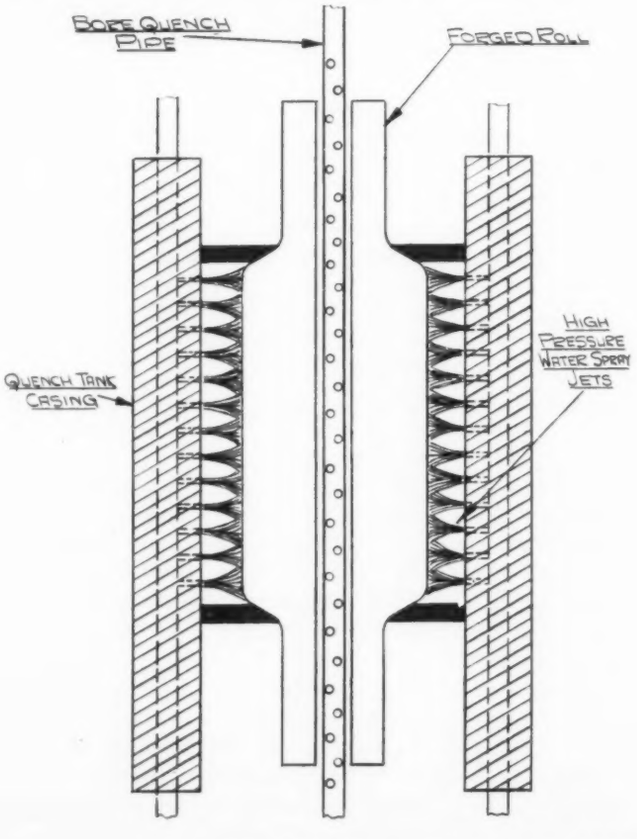
Although this is a very abbreviated account of the service conditions which the forged roll product is expected to meet, it will serve as an introduction to this study of the internal structure of typical forged rolls.

Figure 2 shows a macroetched slab taken from the center of a forged roll hardened by conventional method. This picture shows the heat-treated condition in which this roll was supplied for mill service because the different microstructures in various parts of the roll respond differently to the etching process. The outer rim of this roll section shows the depth to which the hardening quench treatment has been effective (approximately 2 in. in thickness). Close examination of the macroetch photograph, Figure 2, shows an outer layer in the 2 in. hardened rim which has responded to etch treatment with a slightly darker color. This outer layer, which in most rolls hardened by conventional methods is ½ to ¾ in. thick, represents the part of the roll which will have high hardness readings. All of the material in the first ⅜ in. of outer layer of the hardened rim should be above 80 Shore Scleroscope "C" scale when the finished surface is above 95 Shore Scleroscope "C" scale. This point will be discussed further when the microstructures are considered. Our investigations do show there are definite limitations to the penetration limit for drastic quench and for resulting high hardness values.

In order to study the macrostructure of specimens taken from forged rolls such as the body section shown in Figure 2, the specimens must be held in a solution of hot hydrochloric acid for varying periods of time, depending upon the response of the material to the etching process and also depending upon the degree of etching required, as dictated by the purpose for which the etching examination is being made. Since all of the outer 2-in. rim consists of hard type transformation products, it is difficult to bring out by etching in a manner that can be photographed the high hardness surface layer of the hard outer rim. In order to show this condition at all, the photograph must be taken very soon after specimen is removed from etching acid.

The structure in the area of the roll immediately

Figure 3 — Schematic shows an idealized roll quenching system using surface centerbore sprays.



adjoining the outer 2-in. rim is a result of the various heat-treating cycles to which the roll was subjected from the time of its first annealing treatment after casting, through the heating and cooling cycles incident to forging and through the subsequent heat-treating procedures.

Another shaded ring around the center bore section, appearing quite similar to the outer rim, indicates a quenching action has taken place on this area. Examination of many cold mill forged rolls indicates the condition shown in Figure 2 to be the general condition under which cold mill forged rolls are furnished by major suppliers in this industry. However, this end result in structure is obtained by a variety of rather complicated heat-treating and quenching methods which are peculiar to the individual roll manufacturers. The hardening of forged steel rolls for use in cold mills is one of the most difficult procedures known to steel specialty manufacturing. Probably no other steel product must meet the conflicting requirements which are outlined for the manufacture of cold mill work rolls.

While the methods for producing the type structures shown in Figure 2 are extremely varied and the equipment which has been developed to provide this condition may be entirely dissimilar in the various plants in which this work is carried on, nevertheless the general practice can be described very briefly in heat-treating terms. In order to produce this type of structure, the roll must be heated above the critical temperature for the composition and then quenched rapidly through the transformation range. The quenching must be sufficiently drastic to produce a martensitic surface, and the roll must be cooled totally to a temperature which will not permit the condition wherein retained heat in the central portion of the roll can adversely affect the quenched hardness of the roll surface. Therefore when we are discussing rolls with surface hardness values in the range of 95 to 100 Shore Scleroscope "C" scale, it is necessary that drawback of roll surface temperature be held below 200 F, if loss of surface hardness is to be avoided.

Figure 3 is a sketch of an idealized conventional roll hardening quench treatment. The roll has been heated to a temperature above the upper critical and is being quenched with water on all points of the roll surface. For this purpose cold water under high pressure must be used. Note the spray arrangement in the center bore. This bore quench arrangement is used primarily to remove heat from the central part of the roll forging in order that surface quenching may be more effective, and also in order that part of the total heat can be removed in this manner, thereby minimizing the drawback effect of the heat in the central portion of the roll.

The sketch shown in Figure 3 is not supposed to illustrate any exact method in use by any present day manufacturer. It is included simply to illustrate the quenching principle and general method of roll hardening in common use. It would, no doubt, incorporate some of the features of various existing methods.

After being subjected to such a drastic quench treatment, forged rolls must be placed in stress relieving furnaces immediately, in order to avoid failure

Figure 4 — Typical microstructures obtained by conventional method.

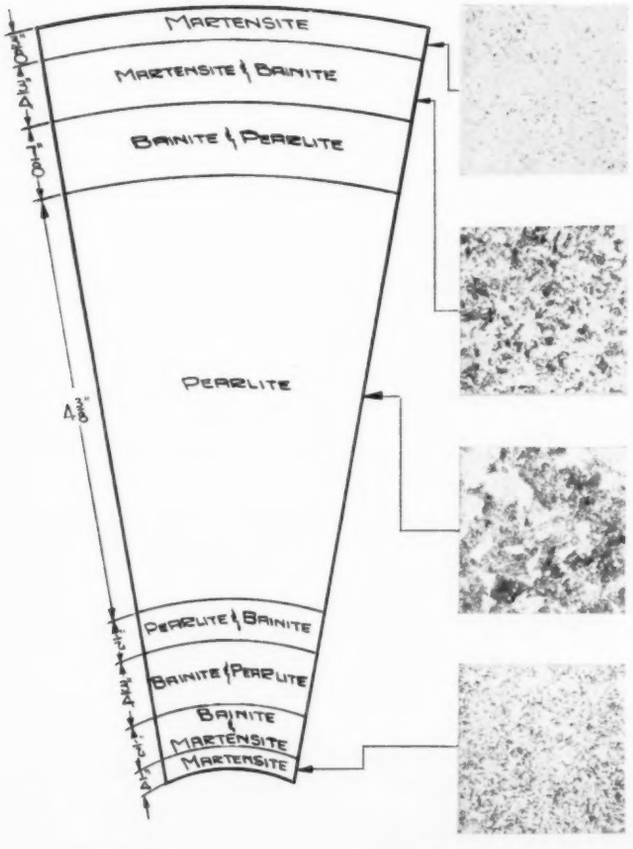
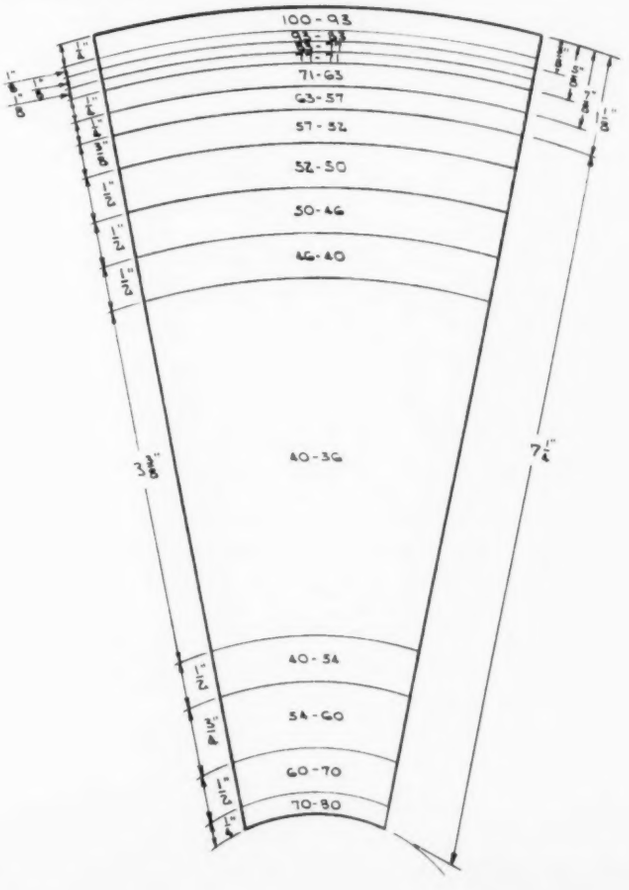


Figure 5 — Typical hardness values obtained in roll by conventional method varies from the peak of about 100 at the surface to about 40 at the quarter point.



due to bursting in the quenched stressed condition. Probably every cold mill operator has had the opportunity to look at examples of rolls which have literally exploded due to the presence of internal stresses.

Figure 4 shows the typical microstructure in the various parts of the hardened roll forging as described above. In Figure 5, hardness values are shown. Hardness values shown in this sketch are representative values taken with a Shore Scleroscope standard "C" scale. Since hardness readings taken with any known type of instrument are liable to error when comparisons are made with any other instrument, either of like or unlike type, the values shown herein are intended to be representative of a range and are not meant to specifically define the limitations of any heat-treating and quenching method.

The stress condition which exists in such a forged roll is extremely complex. Certainly we know the general stress pattern. The outer portion of the quenched roll is in a state of compressive stress; the central portion between the quenched outer layer and the quenched center bore section is in a state of tensile stress, and stresses are acting in radial and longitudinal directions. Sometimes these stresses exceed the physical property limits of the roll forging. At other times a combination of the service-induced stresses along with temperature stresses imposed during rolling, will cumulatively cause roll failure.

The severity of the stress system as outlined above, wherein stresses at all times approach the physical property limitations of the material, means that any variation in manufacturing process can lead to a condition in which failure can occur. The work surface area condition shown in the cross-sectional macroetched slabs is the type of structure which must be provided for present day rolling conditions. The major difficulty with the conventional methods for obtaining this hardness condition lies in the development of the highly stressed condition which accompanies conventional hardening methods. When the entire roll body section is heated above the critical temperature range for the roll composition and then quenched drastically, severe stresses must follow. Because the central section of the roll cannot be cooled rapidly through the critical range, the thermal cycle to which the central part of the roll casting is subjected during the hardening operation, has little, if any beneficial effect upon that part of the roll forging.

Figure 6 — Typical dilatometer curve for a forged steel roll with composition of 0.88 per cent carbon and 1.75 per cent chromium shows critical temperatures.

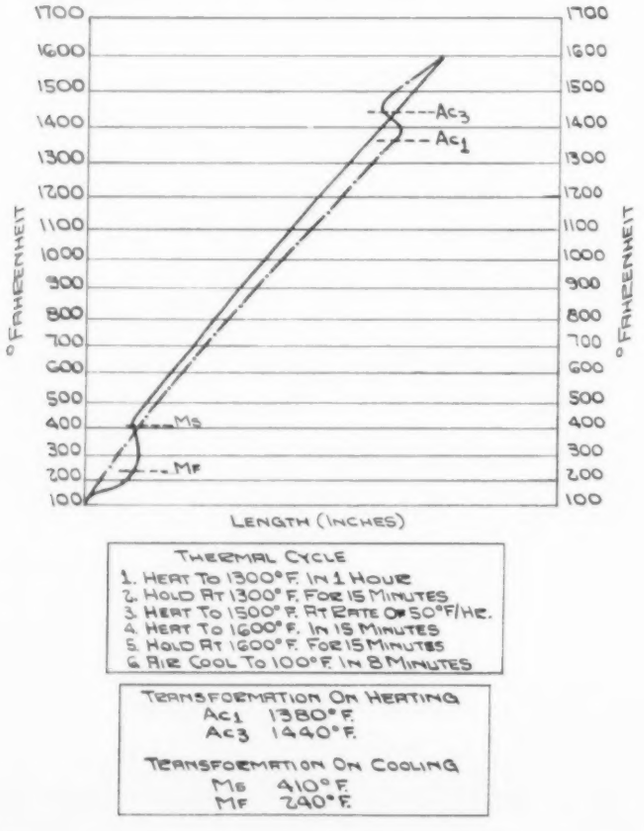


Figure 6 is the chart obtained from a dilatometer study of the forged roll composition. Note this study indicates the upper critical temperature for this composition to be 1450 F; therefore this roll material must be heated above 1450 F and quenched rapidly from 1450 through 200 F in order to obtain a high hardness transformation product. A study of the time-temperature-transformation curve for this composition indicates that rolls made in this composition must be quenched to the martensite transformation zone in less than one minute, if lower hardness transformation products are to be avoided. No quenching means is known which can provide this quenching rate to any great distance below the surface of a 21¾-in. diam roll. The size of the roll, the amount of heat in the roll, the heat conductivity of the roll material, etc., are all factors which make the drastic quenching of the subsurface portion of the roll impossible. Since only the outer area of the roll can possibly be subjected to the drastic quench required, it follows that high temperature conditions in the central portion of the roll only serve to increase the field of possible difficulties. The transformation of the interior area, at a time considerably later than the surface area, creates a complicated stress pattern, and the retained heat in the central portion tends to lower the hardness obtained as a result of the drastic quench treatment on the surface.

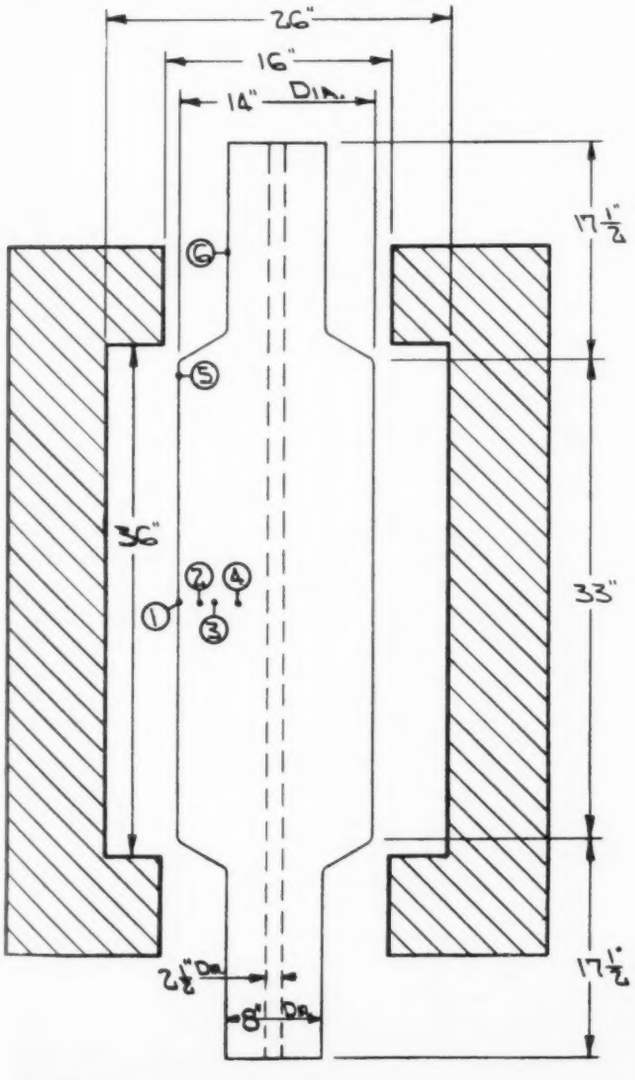
Considering all of the foregoing it was believed that a method, wherein only that area of the roll which would be subjected to drastic quenching would be raised above the critical temperature range while the central portion of the roll was held at a temperature below the transformation range, would have definite advantages in obtaining a high final surface hardness and principally in the avoidance of exaggerated internal stress conditions.

In any conventional heat-treating method, a source of heat, usually a flame, transfers its heat by radiation and convection to the object to be heated. If the heat source is weak, a slow increase of temperature in the body to be heated without noticeable distinction between surface temperature and inner temperature will follow. If the source of heat is strong, the surface temperature of the object being heated will rise more rapidly than that of the layers inside the body of the object. The temperature of the inner layers will depend upon the intensity of the heat source and the thermal conductivity of the object being heated.

Since it has been indicated that forged roll hardening could be carried out with a reduction of quenching stresses if the outer layers of the roll forging only were to be heated for quenching, and since no considered improvement in quality of the inner layers results from the heating and slow cooling of the inner layers incident to the heating for hardening; it follows that a heat source of sufficient intensity to raise the surface layer above the necessary quenching temperature while maintaining the center portion of the roll below transformation changes would meet this condition. However the conductivity of steel roll materials is such that a sufficient depth of surface layer can be heated above the critical temperature range prior to quenching only under the two following conditions, when conventional methods are used:

1. Overheating of surface area (by this is meant heating to a temperature too far above upper critical to obtain optimum quenching results).
2. Penetration of heat into inner layers of roll forging because of length of time necessary to hold surface layer immediately above transformation range.

Figure 7 — A roll was tested in a special gas-fired furnace to determine heating rates. Thermocouple locations are indicated.



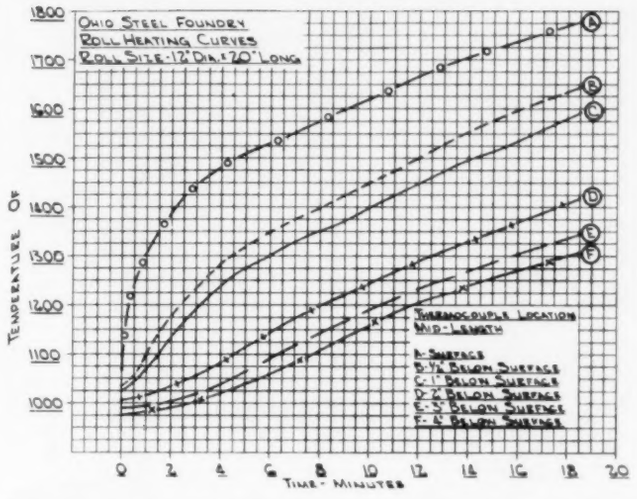


Figure 8 — Chart shows lag in temperature rise as heat progresses to the interior of the roll.

In order to develop this point, the following review of an experimental heating situation is contained in this report as it is believed the heating rates shown here cannot be exceeded in roll heating.

A gas fired test furnace was used (see Figure 7) to conduct heating rate tests to determine whether or not a rate could be obtained sufficiently high to provide a temperature of 1550 F at a distance ½-in. below the roll surface while the remainder of the interior roll body was maintained in an untransformed state. For these tests a maximum surface temperature of 1700 F was observed so that no danger of overheating roll surface would be encountered.

For this experiment, a 12-in. diam by 20-in. long roll section was used. Roll was preheated to a temperature of 1000 F throughout. Following the preheating, roll was placed in the test furnace at a temperature of 1000 F, and heat was applied to the surface at what is believed to be the fastest rate possible with presently available commerical furnaces.

Figure 8 is a chart showing the temperature conditions obtained in this surface heating experiment. Note that it required 18½ min to bring the part of the roll ½ in. below the surface to the quenching temperature of 1650 F. At this time the thermocouple at location "D," 2 in. below the roll surface, had reached a temperature of 1430 F and therefore was in the critical temperature range for this composition. From this, and other like experiments, we concluded that it would not be possible to heat the outer ½ to ¾ in. of roll casting above the upper critical temperature for the material by any radiation plus convection surface heating method while maintaining a top allowable temperature limit of 1700 F, and without having heat conducted into parts of the roll below the outer ¾-in. shell in sufficient quantity to raise at least part of the central portion into the transformation zone. Mechanical difficulties encountered in trying to work out a quenching method to use in connection with a sufficiently fast gas burner progressive heating system do not appear to be amenable to solution.

At this time, early in 1953, we learned about the work being done in Belgium and in Germany in connection with the induction heating for hardening of

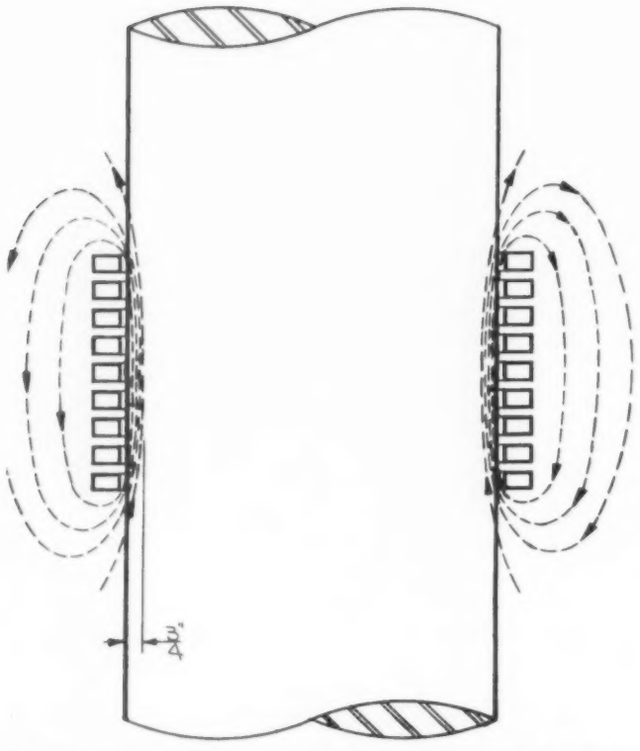


Figure 9 — Induction heating affects the roll surface primarily.

forged work rolls. Investigation of this information and study of their systems led to our adoption of the progressive induction heating method.

Induction heating has been applied to a wide variety of steel objects for a long period of time. During the last ten years there have been tremendous developments in this field. The temperature of steel parts can be increased by induction heating through the transfer of electrical energy from a high frequency heating coil. This heating coil, activated by a power source of suitable capacity, sets up a magnetic field which energizes the steel object so that current flows around its surface. The resistance which the steel object presents to this current flow causes a rapid increase in temperature. The metal object which is being heated does not become a part of the electrical circuit, heating being accomplished entirely by induction.

Figure 9 shows graphically the effect of the application of induction heating, and the above stated very general principle, to a portion of a roll forging. As noted in this sketch, the flux is much weaker on the outer side of the coil and dissipates quite rapidly. The temperature of the object inside the coil rises very rapidly.

Induction heating principles for rolls differ in no way from the rules which pertain to the induction heating of a wide variety of other steel objects; however because of the weight and large sizes of some rolls which must be hardened, very special equipment is required.

In induction heating the following factors must be taken into account, as they control the penetration of hardness which can be obtained.

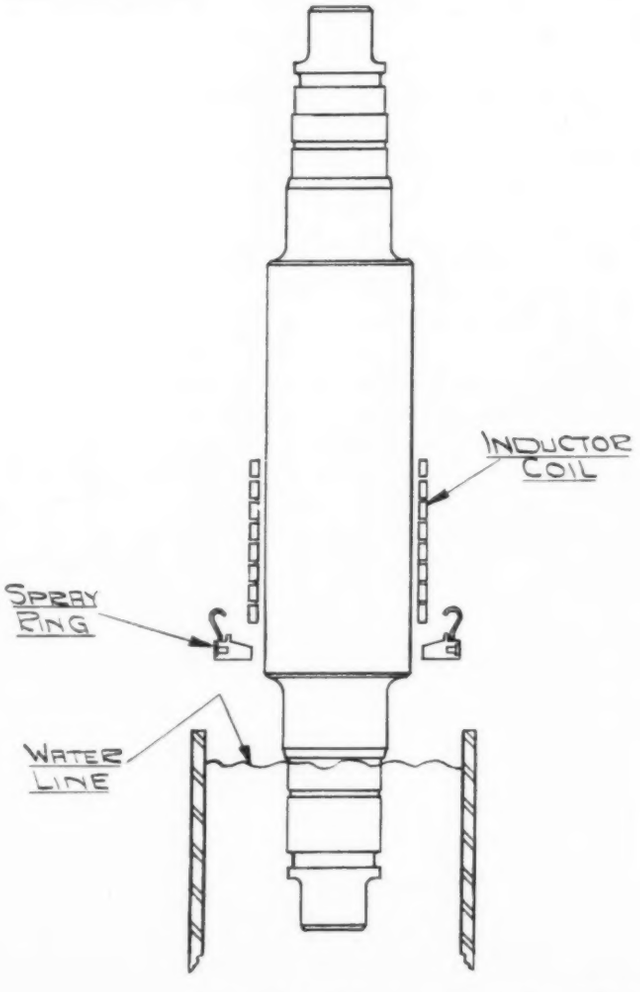
1. The power output of the generator.
2. The frequency.
3. The gap between inductor coil and roll.
4. The resistivity of the roll metal.

In considering the application of induction heating to the roll hardening operation, two possibilities were reviewed; the first, total heating of the roll work surface areas at one time and second, continuous progressive heating of small sections of the work surface area.

It is possible to induction harden a long cylindrical object such as a roll by passing it progressively through the inductor coil where it is heated and immediately following the heating, through a quench ring where it is drastically cooled and hardened. This means that a high power input can be directed to a small longitudinal area of the roll body. It is therefore possible to avoid by progressive heating and quenching the very sizable stress patterns which would result from over-all heating and quenching of the roll surface. Also the progressive system is subject to very close control. The factors of rate of travel, distance from inductor coil to quench ring (which determines time above transformation temperature) and power input are all of extreme importance to the progressive hardening method, but with the equipment which we are now operating, these factors are subject to very close control. In the matter of quenching, water temperature and water pressure are the important considerations.

All of the above factors were considered in developing

Figure 10 — Equipment for progressive induction heating is basically simple. Sketch shows inductor coil, spray ring, and cooling bath.



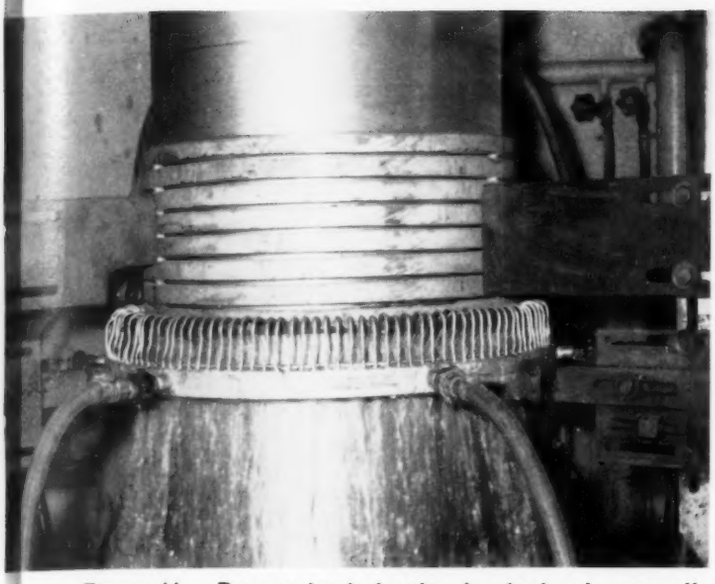


Figure 11 — Progressive induction hardening is normally done with the roll in a vertical position.

an induction hardening practice which will provide a depth of hardness comparable to that shown in connection with the conventionally heat-treated rolls discussed in an earlier part of this report. Although electrical calculations do not show this exactly, because conduction of heat from the outer layer affects the total heat-treat zone, we can with present equipment heat and quench to a high hardness an outer layer $\frac{7}{8}$ in. thick on a 21 $\frac{3}{4}$-in. diam roll. This $\frac{7}{8}$-in. thick layer can be hardened to a level equal to or exceeding that provided by conventional methods. Depth of current penetration differs from the depth of heating penetration because thermal conduction pulls the heat in from the surface, resulting in the heating zone being greater than the depth of the current zone. The heating of this outside layer proceeds very rapidly. Figure 9 shows the depth of current penetration to be $\frac{3}{4}$ in. Thermal conduction will increase this zone of high hardness area to approximately $\frac{7}{8}$ in. for illustrated roll.

Proper quenching of the progressively induction hardened surface is a most important consideration. The downward movement of the roll forging must be regulated so that adequate time above the critical temperature is allowed. The direction of the water jets, the volume of water used and the amount of pressure are all items which must be coordinated. While water temperatures in the range of 50 to 80 F do not greatly affect resulting hardnesses, it has been found in certain experiments a salt water solution can give slightly higher surface hardness values.

Figure 10 is a sketch of a progressive induction hardening installation. This sketch shows a forged roll which is being hardened by passing through the inductor coil and the quench ring located immediately below the inductor coil. The lower part of the roll is entering the water tank into which the roll passes at the completion of the hardening operation.

Figure 11 shows closeup view of roll in inductor coil and in quench ring.

Figure 12 shows possible temperature conditions existing at the surface of a 21 $\frac{3}{4}$-in. diam roll during progressive induction heating. When the Curie point

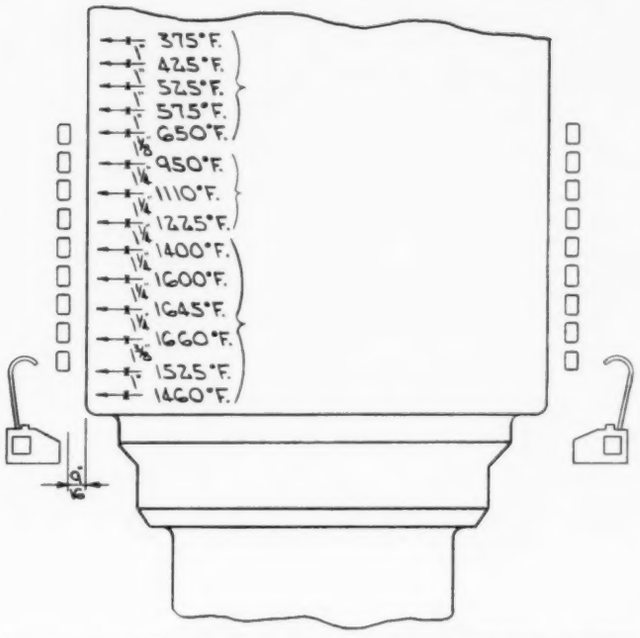
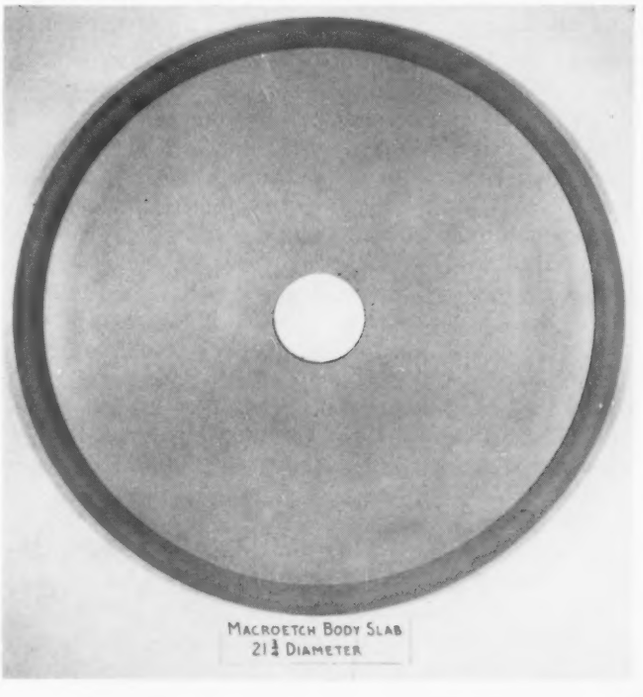


Figure 12 — Temperatures which are developed during hardening operation are shown in the sketch. Other temperature conditions can be created depending on hardening requirements.

is reached, power absorption diminishes markedly. This point is coincident with the critical temperature where magnetic losses cease as a function of heating. At this point the rate of heating becomes much slower. This drop off in rate of heating above the Curie point is the feature which makes induction process particularly suitable for roll hardening.

Figure 13 shows a macroetched slab taken from the center of a forged roll hardened by progressive induction method. This picture shows the heat-treated condition in which this roll was supplied for mill service. The outer 2-in. rim shows the depth to which the prior

Figure 13 — Structure of roll hardened by progressive induction method is shown here in specimen which has been macroetched in hot hydrochloric acid solution for 35 min.



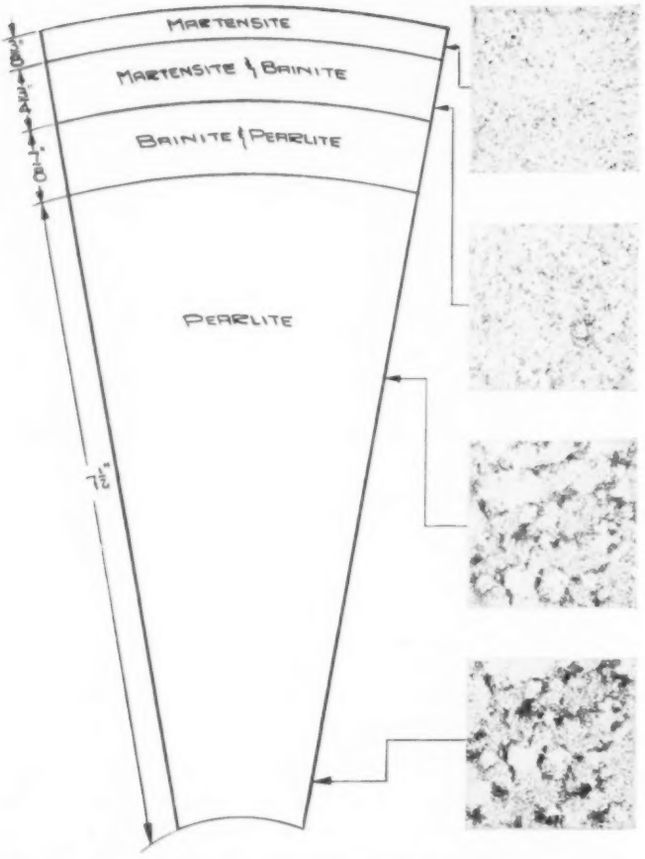


Figure 14 — Typical microstructures obtained by induction method.

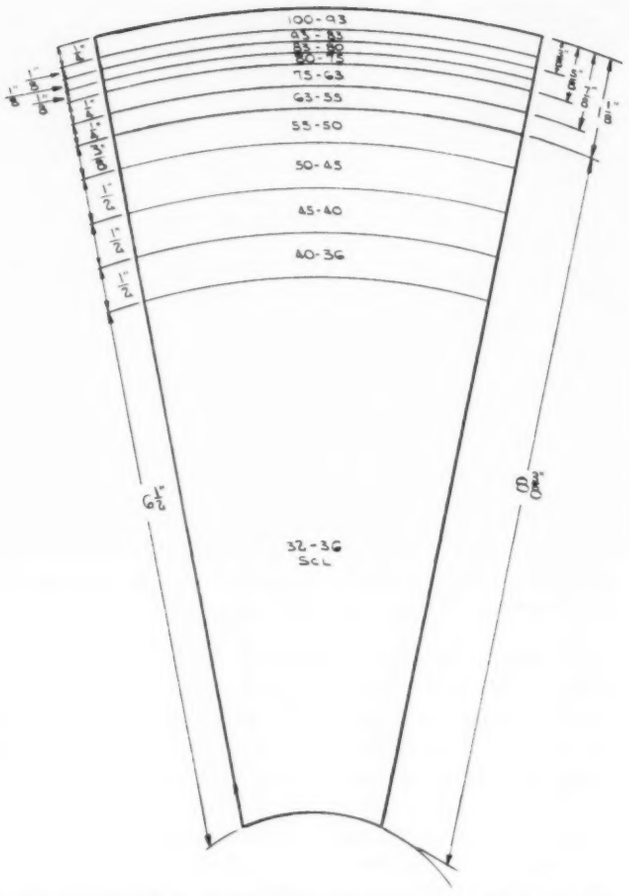


Figure 15 — With induction method typical hardness values vary from the peak at the surface to the minimum at the roll center.

conditioning quench treatment was effective. The outer 7/8-in. layer of this 2-in. hardened rim, which responded to etch treatment by turning a much darker color, is the part of the roll which has been changed to a high hardness level by quenching after induction heating. The 2-in. rim shown in this figure is a result of the prior conditioning treatment which is also a drastic quench treatment. However since this quenching result is obtained in a prior quench treatment it is possible to eliminate all stresses caused by conditioning treatment quench by giving roll a high temperature stress relief treatment after conditioning treatment but before final induction hardening operation.

Rolls which are to be heated for hardening by induction must receive prior conditioning heat-treatments in order to have correct microstructure which will respond properly to the induction heating. The time for the material in the surface area of the roll to be above the critical temperature is very short and the prior microstructure has a most important bearing upon the obtaining of complete austenization. In order to obtain full hardness, full solution of the microconstituents is necessary. Exhaustive tests were made in our laboratory to determine the proper prior microstructure which would respond to the induction heating method. This work had to cover the range of compositions which we expected to use.

A description of the structure and hardness condition of this roll is contained in the following pages with representative photomicrographs. The structure in the area of the roll immediately adjoining the outer 2-in. rim is result of the various heat-treating cycles to which the roll forging was subjected. It should be noted in connection with this photograph that etching treatment has not revealed a hardened area around the center bore. With induction heating and quenching, center bore quenching is not required. This serves to simplify the stress pattern which results from the heating and quenching process.

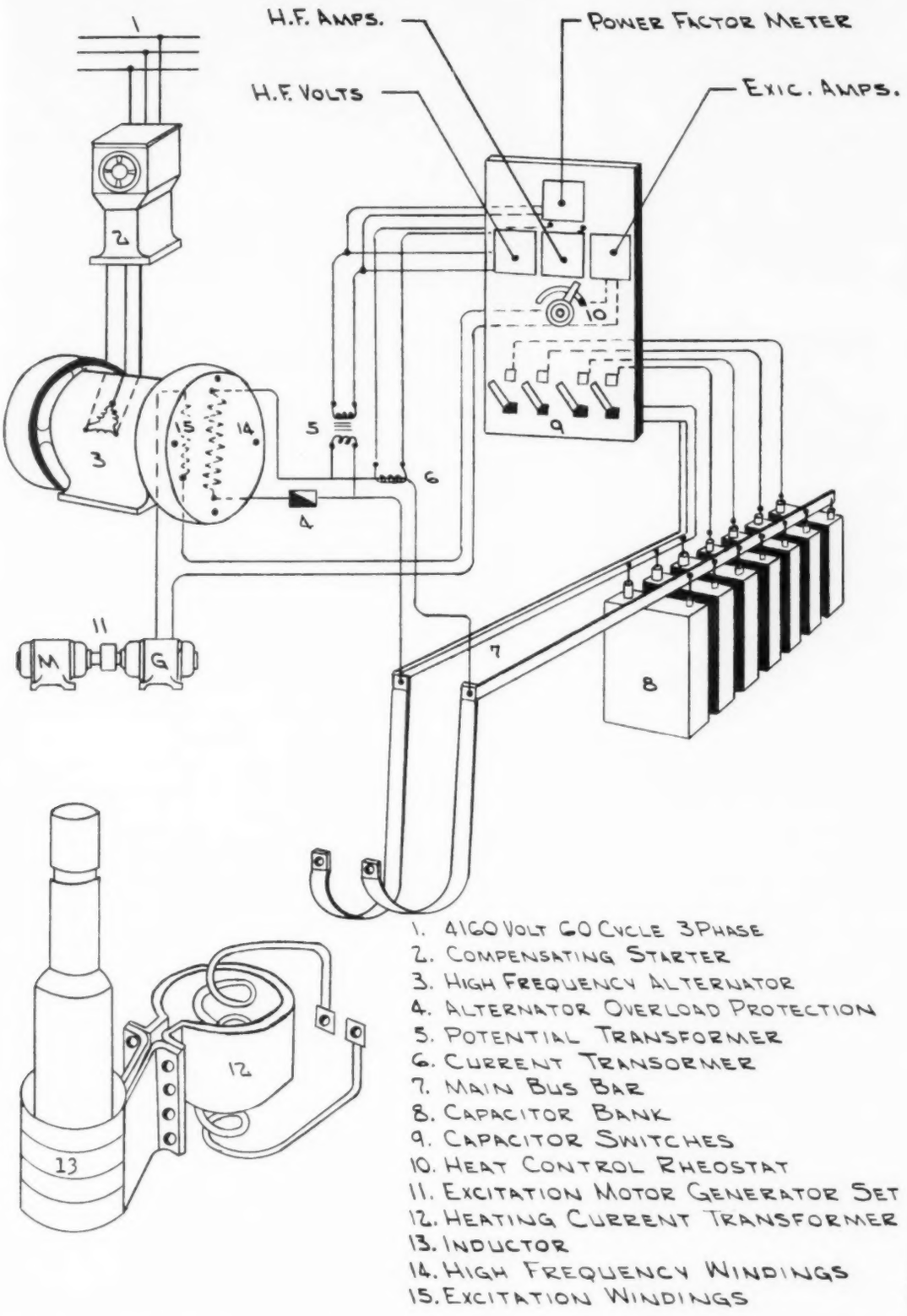
Figure 14 shows the typical microstructure of the various parts of the hardened roll forging from the working surface to the center bore. Typical hardness values for rolls processed in this manner are shown in Figure 15. (See comments concerning hardness readings in connection with discussion of Figure 5.)

Figure 16 is a schematic view of the induction hardening equipment installation showing the various parts required to carry out this process. The various parts of this equipment are labeled in the drawing and are readily identifiable.

Figure 17 shows a progressive induction hardening machine which is used for processing rolls in the 20-in. class, designed and built by a firm located in Herstal, Belgium. This equipment was built to operate at a frequency of 1200 cycles as research work has shown this to be the optimum range for roll heating work.

The inductor coils are designed to allow a gap which will provide a depth of hardness comparable to that shown in connection with the conventionally heat-treated rolls discussed in an earlier part of this report.

In Germany, another company has also worked in this field. This company builds a large size progressive induction hardening machine but has attacked the



1. 4160 VOLT 60 CYCLE 3PHASE
2. COMPENSATING STARTER
3. HIGH FREQUENCY ALTERNATOR
4. ALTERNATOR OVERLOAD PROTECTION
5. POTENTIAL TRANSFORMER
6. CURRENT TRANSORMER
7. MAIN BUS BAR
8. CAPACITOR BANK
9. CAPACITOR SWITCHES
10. HEAT CONTROL RHEOSTAT
11. EXCITATION MOTOR GENERATOR SET
12. HEATING CURRENT TRANSFORMER
13. INDUCTOR
14. HIGH FREQUENCY WINDINGS
15. EXCITATION WINDINGS

Figure 16 — Layout of roll induction heating installation.

problem of hardening small forged rolls in a different manner.

Figure 18 shows the induction hardening machine which we use for processing small forged rolls. Rolls ranging in size from the very smallest rolls made, up to approximately 10 in. diam by 14 in. body length, can be processed in this machine. A special feature of this machine is the elliptical inductor coil. In such small rolls, stresses are not so extensive; consequently the entire working surface area of such rolls can be heated and quenched at one time. The inductor coil in this machine is made in an elliptical shape so that by simply turning the coil adjustments for various body lengths may be quickly accomplished. At the completion of heating, the coil is moved away and the quenching ring shown in the left of the figure moved over the heated roll surface. Entire surface is quenched at one time. Following this quenching treatment, rolls must be stress relieved.

As noted previously, in many mills it is possible to use rolls at a diameter reduced below the diameter at which the original hardening treatment was ef-

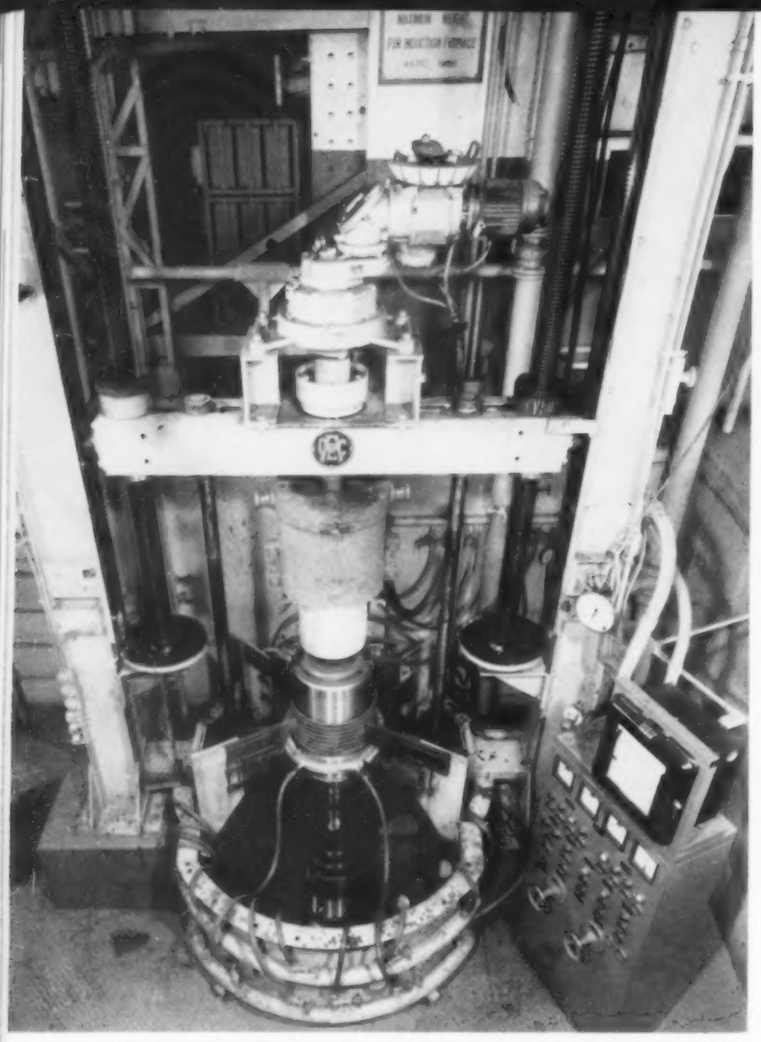


Figure 17 — This progressive induction hardening machine handles rolls in the 20-in. class.

fective. Such rolls must be rehardened when the original high hardness surface layer has been removed during initial service period. Rehardening rolls of this type has been a serious problem for conventional hardening methods. The journals are finished to very close tolerances when rolls are originally furnished, and these tolerances must be maintained during any rehardening operations. If the heating and cooling cycles incidental to the rehardening operation cause warpage or any deviation from finished bearing tolerances, the journal areas must be rebuilt and remachined. These are costly operations.

Forged and hardened steel rolls which are to be rehardened must first receive a tempering treatment to remove all of the stresses created by the original hardening or imposed on the roll through mill service. Figure 19 is a cross-sectional view of an induction tempering installation. With this type of treatment, it is possible to adjust the heat zone so that only the body section of the roll is subjected to high tempering temperature treatment. The temperature of the roll journals is maintained at a very low level, and no warpage occurs. Following this tempering treatment and after machining operations to provide defect free body wearing surface, the roll can be rehardened using high frequency induction equipment described in the foregoing part of this report. By this method rolls having high body surface hardness with unchanged journal bearing areas can be supplied as rehardened rolls.

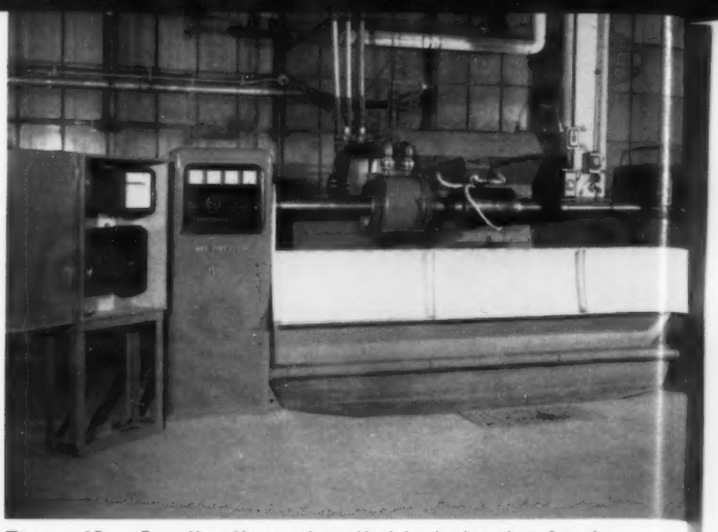
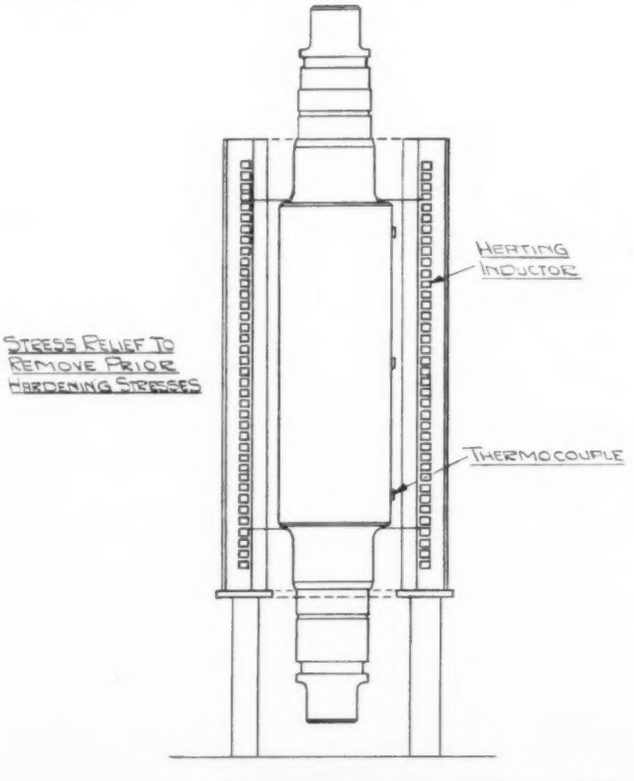


Figure 18 — Small rolls are handled in induction hardening machines of a somewhat different type than those used for the large rolls.

Figure 20 shows one of the low frequency induction furnaces which we use for the tempering of used rolls which are to be rehardened. In this figure, the induction coils with the adjustable taps are shown. With this type of equipment the operation described in connection with Figure 17 can be performed.

Sometimes the statement is made that better service life is received from rehardened rolls than from rolls which receive only an original hardening treatment. From this belief the implication follows that rehardening carries some special quality which cannot be supplied in the original hardening operation. While there may be some incomplete statistical background for this idea, it is not a matter of theoretical or actual fact. It is possible to supply a roll in the original hardened condition which can match in every way the same roll in a rehardened state. In some mills rehardened rolls do show a statistical advantage in

Figure 19 — Cross-section shows an induction tempering furnace.



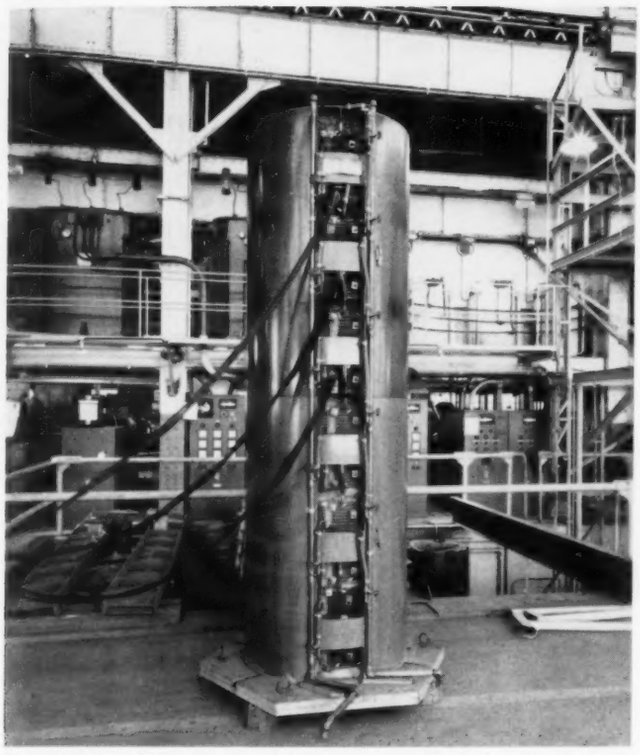


Figure 20 — Furnace used for tempering used rolls is a low frequency induction unit.

their service life history. This situation is the result of the following causes:

1. Those rolls which contain inherent defects such as unrelieved quenching stresses are usually eliminated during the period of original use and become an unfavorable influence on the statistical average showing for rolls used as originally hardened. Any defects caused by the various steps in the manufacture of a forged roll are most often discovered during use in the originally hardened state.

2. The original hardening treatment may have created a dispersion of carbides which may be a superior prior structure for the second or subsequent hardening treatments, and better service life in such cases may be obtained from rehardened rolls.

Tables I, II, III, IV, V contain exact information on amount of reduction being obtained from the original hardening from rolls which have been hardened by conventional methods. Various types and sizes are included in this survey which includes a large number of rolls recently processed.

The microstructure in the wearing surface areas of rolls which have given the type of service shown in these tables can be duplicated readily by the progressive induction hardening method and at the same time excessive internal stress conditions can be avoided. Because of this and considering the fact that rolls to be rehardened can be processed without danger of journal warpage, widespread adaptation of induction heating process to forged roll hardening operations is anticipated.

TABLE I
Temper Mills

Type	No. stands	Work roll size, in.	Average reduction on radius, in.
4-High	2	9½ x 44	0.400
4-High	2	19 x 42	0.380
4-High	1	19 x 56	0.400
4-High	2	19½ x 42	0.300

TABLE II
Cold Reduction Mills (Reversing)

Type	No. stands	Work roll size, in.	Average reduction on radius, in.
4-High	1	21½ x 54	0.330

Discussion

PRESENTED BY

A. A. BRADD, Co-ordinator of Rolls, Midvale-Heppenstall Co., Nicetown, Philadelphia, Pa.

JOHN DUGAN, Works Manager and Chief Metallurgist, The Ohio Steel Foundry Co., Lima, Ohio

A. A. Bradd: There is so much black magic about the hardening of rolls that it is really refreshing to hear the type of presentation given by Mr. Dugan.

We have been induction hardening rolls at our company for over 25 years. We do not use the progressive method. In our process, the entire surface of the roll body is heated at the same time. We can heat the roll surface to the hardening temperature and then cut the power back and hold it at that temperature for as long as we wish. By this process we can produce the type of hardening pattern shown in Figure 13 of Mr.

TABLE III
Skin Pass Mills

Type	No. stands	Work roll size, in.	Average reduction on radius, in.
2-High	1	32 x 60	0.620
2-High	1	30 x 52	0.460

TABLE IV
Cold Reduction Mills (Tandem)

Type	No. stands	Work roll size, in.	Average reduction on radius, in.
4-High	3	11½ x 24	0.350
4-High	4	18½ x 54	0.530
4-High	4	19 x 52	0.350
4-High	4	19 x 56	0.360
4-High	5	19½ x 42	0.490
4-High	3	19¾ x 66	0.450
4-High	3	20¾ x 93	0.460
4-High	5	21 x 42	0.390
4-High	5	21 x 48	0.400
4-High	4	21 x 80	0.300
4-High	5	21½ x 42	0.330
4-High	5	21½ x 44	0.450

TABLE V
Cold Reduction Mills (Single Stand)

Type	No. stands	Work roll size, in.	Average reduction on radius, in.
4-High	1	20¾ x 93	0.460
4-High	1	17 x 56	0.490

Dugan's paper or we can hold the roll at temperature until the heat soaks all the way through and we can produce the type of pattern shown in Figure 2, or we can stop anywhere in between. Our process permits quite a bit of flexibility in the hardening pattern we can produce.

Depth of hardening is always an important subject in rolls. If I read Figure 15 correctly, Mr. Dugan shows about 85 Scleroscope $\frac{3}{8}$ in. under the surface. Using our induction hardening practice, we can easily obtain over 90 C Scleroscope a half inch under the surface of a 20-in. roll. On some experimentally hardened $12\frac{1}{2}$-in. diam rolls we have produced as high as 90 C Scleroscope $1\frac{1}{4}$ in. under the surface. These figures are cited to show the variation in depth of hardening that we can get with our hardening practice.

In Figure 8 Mr. Dugan shows the heating rate obtained after preheating a roll to 1000 F and charging it into a furnace running at 1000 F and heating as rapidly as possible to produce heat penetration below the surface. I would like to suggest that a faster heating rate could probably have been obtained if the hardening furnace had been at or above the hardening temperature when the roll was placed in it.

One thing that worries us in our induction hardening and has given us some trouble is the presence of a soft layer too close to the rolling surface. If a roll has been quenched and drawn before being induction hardened, the rapid heating of the surface will produce a temperature gradient so that below the layer that will be hardened is a zone that will be above the draw temperature used to produce the core hardness of the roll but below the temperature that will produce hardening. When this happens, a very soft zone is produced under the hardened layer. Our stress people tell us that stresses of the order of 50,000 to 75,000 psi and higher are produced under the rolling surface of work rolls. As a roll is ground down, the very soft area will come closer and closer to the surface, where the working stresses become higher and could result in having material too weak to take the working stresses. We adjust our hardening practice so as not to produce a layer of very soft material directly under the outer hardened zone where some rolls are highly stressed.

John Dugan: The following answers to Mr. Bradd's comments are presented in the order in which they were given.

The experience using stationary induction heating method is a matter of rather general knowledge. We have examined the internal structure of a great number of rolls produced to this method, and the following table shows the general service results obtained from rolls produced by this process, which we have studied. In this connection I should like to refer to the section of the paper in which Figure 5 is discussed. In that discussion, statement was made, "Since roll hardness readings taken with any known type of instrument are liable to misinterpretation when comparisons are made with any other instrument either of like or of unlike type, the values shown herein are intended to be representative of a range and are not meant to specifically define the limitations of any heat-treating and quenching method." We think the amount of reduction obtained in service is the absolute test of roll suitability. Table VI shows the service record of a large number of rolls produced by the stationary induction hardening method.

Table VI
Service Record of Rolls Produced by Stationary Induction Practice

Type mill	No. stands	Roll size, in.	Average reduction on radius, in.
4-High tandem	3	$11\frac{1}{2}$ x 24	0.376
4-High tandem	2	12 x 60	0.401
Temper mill	2	19 x 42	0.298
4-High tandem	3	$19\frac{5}{8}$ x 66	0.360
4-High cold reduction	1	20 x 70.866	0.420
4-High cold reduction	2	$20\frac{1}{4}$ x $70\frac{7}{8}$	0.391
4-High skin pass	1	$20\frac{1}{2}$ x 74	0.428

You will note the service obtained from rolls produced by this method closely approximates the service records shown in Tables I, II, III, IV, and V for rolls produced by conventional hardening methods.

With regard to depth of heating possible with the stationary induction method, we think the practice of heating a roll all the way to the center before quenching removes the unique advantage of the induction method, in that a roll heated in this manner would be subject to the same excessive stress conditions on quenching which are present in rolls heated by the conventional method as described.

One of the most important considerations in a control of the depth of heating zone is the air gap between the inductor coil and the object being heated (see discussion concerning Figure 9). Because of the relatively simple construction of the inductor coils used with the progressive induction heating method, it is possible and practical to have inductor coils for all diameters of rolls and for all required heat penetration conditions.

The chart (Figure 8) showing rapid heating rate was included as being indicative of the various heating experiments which we had performed. No attempt was made to review the various experiments, and this one chart was included as it is believed this information can be of value to people concerned with heat transfer rates. We certainly would not want to have preheated the hardening furnace to a temperature above the hardening temperature since one of the stated limitations was holding the surface temperature of the piece below 1700 F.

The presence of a soft layer close to the rolling surface noted in Mr. Bradd's closing comment has not been observed in rolls produced to the progressive induction hardening method, nor has it been observed in rolls examined by us produced to the conventional hardening method. We are inclined to think such an occurrence could be due to the quenching means employed rather than that it should be a result of the heating method used. A quenching means which would not satisfactorily transform the amount of the roll body which was heated above the critical temperature might produce the condition noted by Mr. Bradd in the subsurface area which would be quenched at a rate which would permit mixed transformation products.

In a new process, which progressive induction heating for rolls certainly is, many new developments can be expected. We think many rollmakers will adapt some form of this process to their roll hardening methods in the very near future. ▲

Blast Furnace Operation With Western Raw Materials

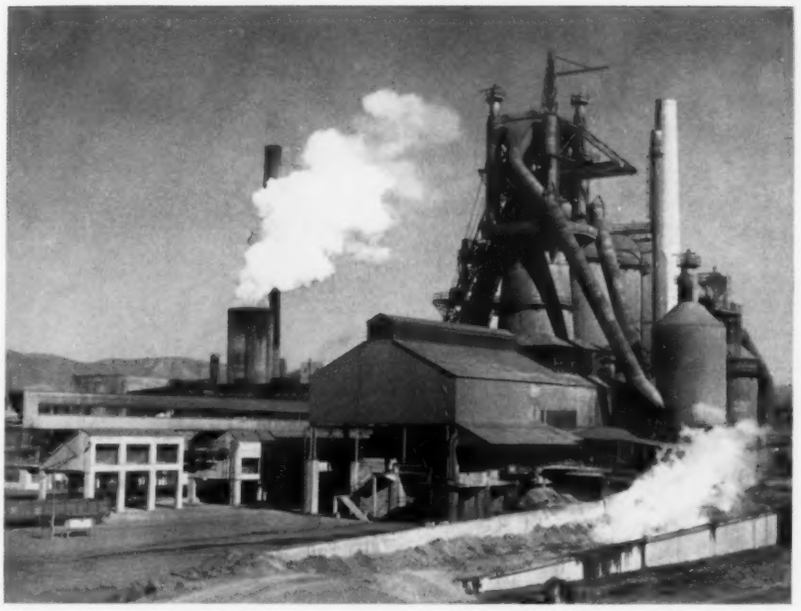


Figure 1 — Original blast furnace was built in 1942 with hearth diameter of 25 ft-6 in.

by J. D. Saussaman,

Division Superintendent, Iron and Steel, Kaiser Steel Corp., Fontana, Calif.

. . . . because of poorer raw materials, Western blast furnace operators have had to set up procedures to overcome many operating problems . . . . their solution, in the future, will be helpful to Eastern operators as their supply of high grade ores decline . . . .

KAISER Steel Corp.'s first 1200-ton blast furnace was the proving ground for developments in blast furnace practice which digressed far from accepted Eastern methods and brought to light the importance of raw material beneficiation. Built at the height of the war, No. 1 Furnace (Figure 1) was blown in on December 31, 1942, in a location new to the steel industry.

Although the furnace was not the first blast furnace in California, it was the first successful one. In the early days, the West boasted several iron-smelting furnaces, all of short duration and early vintage. The first furnace was erected at Cedar City, Utah, by the pioneer Mormons in 1852 to make iron for the new settlement in the Salt Lake Valley. Later, in 1867, an effort was made at Oswego, Ore., to establish a charcoal blast furnace for smelting the limonite ore discovered at that locality. Again, in 1881, two further attempts were made to smelt local ores, one at Clipper Cap, Calif., and one at Irondale, Wash. None of these projects on the pacific coast has survived to the present, in spite of numerous reorganizations and furnace rebuildings.

Until the Fontana blast furnace was built and became a successful producer, many men in the steel industry claimed that basic iron could never be made economically in California due to the variable analyses and inconsistent physical make-up of Western ores. Compared with uniform Eastern raw materials, those mined in the West are seemingly inferior. The coal makes weak coke, the limestone is crystalline rather than amorphous, the ore is high in sulphur, and the chemical analysis of all these materials varies greatly from one sampling to the next, but, as has been proved at Fontana, these disadvantages can be overcome. The steel plant has been continually expanded until today three 1200-ton blast furnaces are in operation, and a fourth furnace is under construction (Figure 2).

An economical blast furnace operation, regardless of where it is attempted, can only be obtained if good raw materials are available to charge into the furnaces. The good ore available in the Mesabi regions of Minnesota and the good coking coals available in the East and Middle West were the basic raw materials for furnaces in this country for many years. These good raw materials are not available in the West, and so

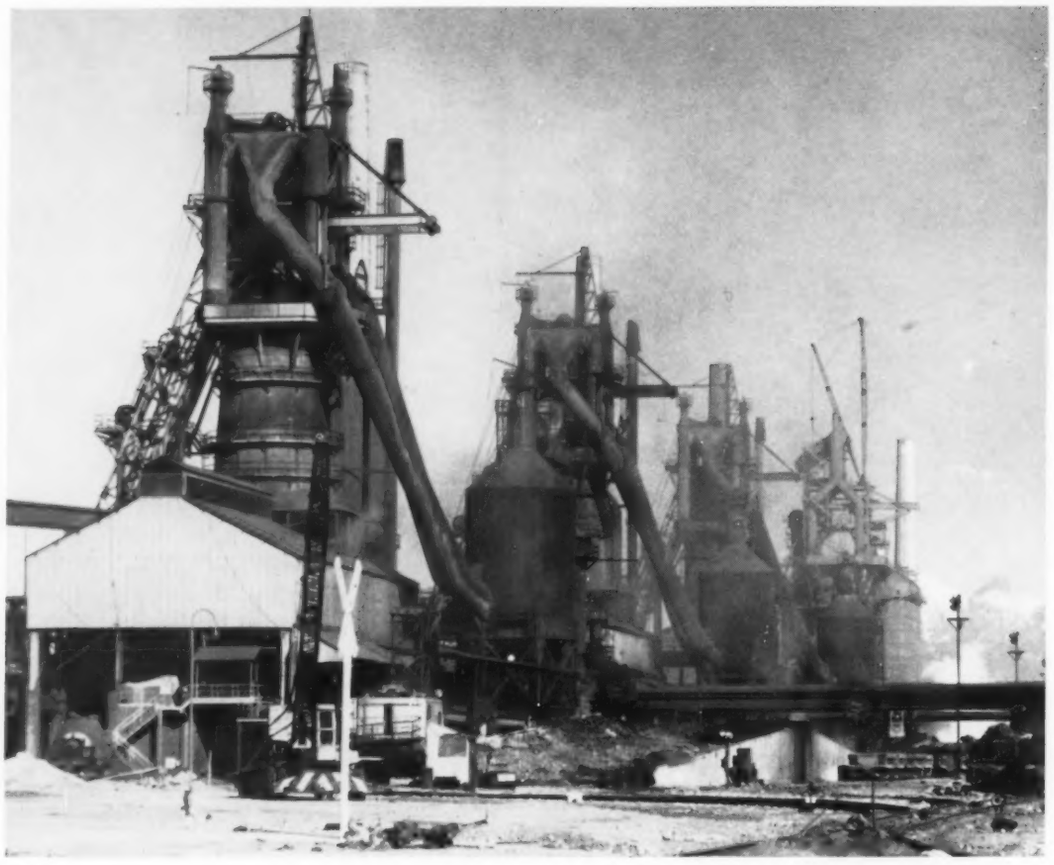


Figure 2 — Three identical 25 ft-6 in. blast furnaces are now in operation. The fourth furnace, with 29 ft-6 in. hearth diameter, can be seen under construction in the background.

it is necessary to take steps to improve the physical and chemical properties of the available raw materials if efficient furnace operation is to be obtained.

Just what takes place within the blast furnace has been the subject of considerable thought and investigation for the past hundred years. Inasmuch as the materials are charged into the top and removed from the bottom of a closed furnace, it is difficult to determine exactly what transpires at each step throughout the process. The process is basically very simple and is practically the same as has been used for many years. Each year has seen changes in the size of furnaces and in auxiliary equipment, but very few changes in the basic process have been made in the past 200 years.

Iron ore, limestone and coke are charged into the top of the furnace in proper proportions depending on their chemical analysis and the type of iron which is to be produced. The iron ore furnishes the iron, the limestone is needed to combine with the waste material of the ore and coke to form the slag. The coke contains the carbon which is needed to produce heat and also the reducing gas (CO) necessary to complete the reduction of the iron from the ore.

The preheated air entering the furnace through the tuyeres comes in contact with the incandescent coke which has traveled down with the stock column and is the one remaining solid at the tuyere zone. Upon contact with the air, the coke is burned ultimately to carbon monoxide (CO) gas. The gas leaving the combustion zone is composed almost entirely of the carbon monoxide (35 per cent) and the inert nitrogen (65 per cent) coming in with the air blast. The gas is highly "reducing" in nature and as it proceeds up through the column, the carbon monoxide (CO) reduces the oxygen from the iron oxides and other metallic oxides and itself is partially oxidized to carbon dioxide (CO_2).

The reduction in space caused by burning the solid coke to gaseous carbon monoxide in the tuyere zone creates a void and the stock in the furnace, therefore, starts to descend toward the furnace hearth through regions of higher and higher temperature. At different levels, then, the chemical reactions peculiar to the temperatures will occur. In the zone of fusion which probably extends down to within a short distance from the bottom of the hearth, the slag and iron, both now in the liquid state, trickle down through the voids in the coke. In the hearth, the slag and iron separate by gravity into two layers: (a) an upper or slag layer, and (b) a lower or metal layer. In the hearth, these two layers are in contact with each other and with the unburned coke.

Ore contains clay and sand besides the iron oxide. In addition to carbon, the coke contains approximately 10 per cent ash and 0.95 per cent sulphur. The ash in the coke and the gangue in the ore combine with the CaO in the limestone to form the slag.

At this point, it is possible to point out certain basic principles of furnace operation:

1. The amount of slag produced must be kept at a minimum as it is a waste product at Fontana and increases the cost of hot metal. Slag production can be reduced by lowering the per cent of gangue in the ore (thus increasing the Fe content) or by lowering the per cent ash in the coal (thus increasing the carbon content).

2. Inasmuch as hot metal for the basic open hearth must be low in sulphur content, the sulphur content of the raw materials should be as low as possible. The slag actually removes the sulphur from the iron, however, its saturation point is low and so the best

method of sulphur control is to reduce the amount charged into the furnace. The ores and coke generally used in the East are much lower in suphur than those available in the West.

3. The ore must be crushed and screened to the proper size. As explained above, reduction takes place by CO gas coming into contact with the surface of the ore particles. If the ore is hard and dense, it must be crushed relatively small so more surface is exposed to the reducing gas.

Crushing produces an excessive amount of fine ore ($-\frac{3}{8}$ in.) which if charged into the furnace would be blown out by the rush of gases leaving the top of the furnace. This dust lost can be reduced by screening the fines from the ore and agglomerating them into larger pieces by the sintering process.

4. The coke fills about two-thirds the volume of the furnace and must be physically strong enough so it will not crush excessively. If it crushes, it is impossible for the gases to pass through the furnace. No gas passage, no wind blown, no coke burned, no production. One of the surest ways to go out of the blast furnace business is to try to operate on extremely weak coke.

5. All materials must be as uniform as possible, both chemically and physically. Hour-to-hour variations in materials make efficient furnace operation nearly impossible. If economics were not a factor, an extremely good furnace operation could be obtained anywhere in the world by buying high grade, low sulphur ore from Labrador or South America and good coking coals, low in ash and sulphur from the Eastern United States. With such raw materials, record production rates on any blast furnaces would be possible, but it would not be a profitable operation. Economic furnace operation is not the result of some secret operating techniques known only to a few people, but rather is the result of having inexpensive raw materials of reasonable quality.

Kaiser Steel Corp. has basic raw materials to last for many years relatively close at hand. These materials are not ideal from the viewpoint of the furnace operator, but an ever-continuing program of beneficiating these materials has resulted in a reasonably successful blast furnace operation.

It should be quite evident from the above discussion that the first step in the blast furnace process starts at the raw material mines (Figure 3).

SUNNYSIDE COAL MINE

This mine, located 700 miles from the steel plant, has furnished about 85 per cent of the Fontana coal requirements since 1942. As mentioned previously, the amount of ash and sulphur in the coal should be as low as possible. On this score, Sunnyside coal is not as good as that used by most of the steel industry, but it is satisfactory. As coal mining has become more mechanized, the amount of rock and ash in the coal has increased. This necessitated the modernization of the washing plant in 1953. At the present time, all the coal is washed to reduce the ash from 15 to 20 per cent to approximately 6.5 per cent.

The Corporation is currently operating three mines in the Sunnyside area, and the coal from all three is discharged into a large blending bin before being fed into the washing plant. This is the first step of blending in an effort to level out chemical and physical variations in the coal.

The most detrimental quality of this coal is its weak coking ability. Coke produced from 100 per cent Sunnyside coal is extremely fragile and will disintegrate to fines in the furnace. To overcome this deficiency, about 15 per cent low volatile coal is blended with the Sunnyside to improve the strength of the coke. The low volatile coal is purchased from several mines in the Oklahoma area.

Due to the fact that each coal has different chemical and coking properties, they must each be stored separately after being received at the steel plant, and then reclaimed into separate mixing bins. From these bins, the coals are blended in correct proportions to make a coal mixture which will produce the best possible

Figure 3 — Location of steel plant is shown with relation to major raw material mines: (1) iron ore—Eagle Mountain, California; (2) coal—Sunnyside, Utah; Raton, New Mexico; (3) limestone —Cushenbury, California.

coke, physically strong and chemically uniform. After leaving the mixing bins, the coal passes through hammermills which pulverize the coal as well as complete the blending of the coals. The pulverization is controlled so that 70 per cent of the coal is minus $\frac{1}{8}$ in. and less than 10 per cent exceeds $\frac{1}{4}$ in. in a further effort to improve the physical properties of the coke.

The beneficiation of Sunnyside coal is not much different from that carried on by other steel companies, as the economies to be obtained by low ash, low sulphur, strong coke are appreciated throughout the industry. In fact, most blast furnace coke produced in this country is superior to that used at Fontana.

To supplement its coal reserves, the Corporation recently purchased extensive coal properties in the vicinity of Raton, N.M. This coal is currently not being used at the plant, but will be used following the completion of the present expansion. This coal will produce a stronger coke with lower sulphur content, however, the ash content will be higher.

CUSHENBURY LIMESTONE

Limestone can be considered a necessary evil in the blast furnace process. It furnishes CaO to combine with the gangue in the ore and the ash in the coke to form a fluid slag. It also controls the basicity of the slag which is the controlling factor in removing sulphur from the hot metal.

Prior to this year, the stone was purchased from suppliers in California and Nevada. Early this year, the Cushenbury deposit located at the east end of Lucerne Valley was opened.

This deposit contains stone of various qualities some containing less than 2 per cent SiO_2 and more than 54 per cent CaO which is a very good blast furnace stone. Some of the stone is lower grade and is suitable for the production of cement. By selective mining, the two stones are separated, the steel plant getting the higher grade, and the cement plant getting the lower grade.

The stone for the blast furnace is crushed and screened at the mine to a size specification of 3 x $\frac{1}{2}$ in.

EAGLE MOUNTAIN ORE

The Eagle Mountain ore mine is located about 160 miles southeast of the plant, near Desert Center in the Colorado Desert. This ore deposit was found many years ago, but was of no practical value until blast furnace operation was started in California. The ore was first mined in 1948 and since that time has been the only ore normally charged into the furnaces. It is the key to economical operation at Fontana and will continue to be for many years. The total amount of ore at Eagle Mountain is not yet known, as the deposit consists of over sixty ore bodies, varying in size from $\frac{1}{4}$ to $1\frac{1}{4}$ miles wide, and extending over six miles in length. To date, all of the deposits have not been drilled.

At present the ore is being mined by the open pit method from two of the deposits called the North and South deposits (Figure 4). The ore averages about 48 per cent Fe. This compares favorably with ores being mined in the Mesabi region, but is low grade when compared with foreign ores. The ore is hard and dense and requires proper sizing before charging into the furnace if efficient reduction is to take place. This is in contrast to the Mesabi ores which are rela-

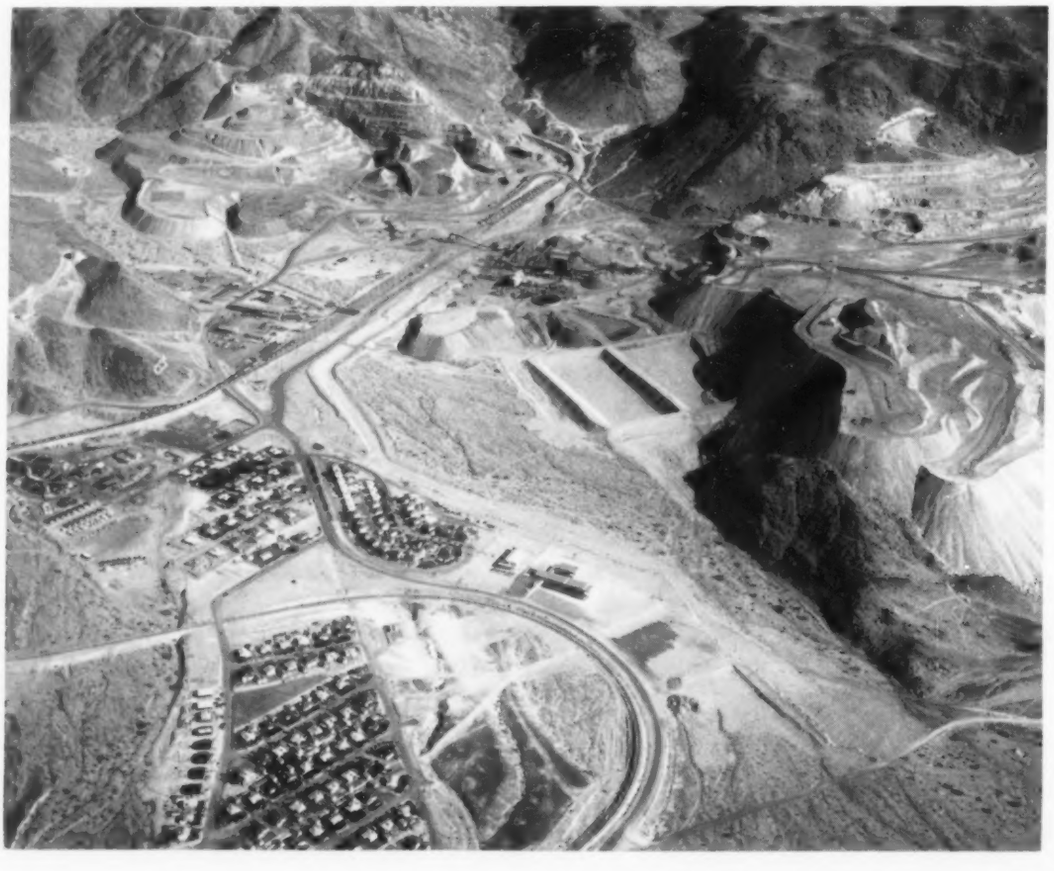


Figure 4 — General view of Eagle Mountain Mine shows the open pit mining on the right, the beneficiation plant in the center, and the town in the lower left.

tively soft and easily reduced. The sulphur content of the ore averages 0.3 to 0.6 per cent and is much higher than is generally accepted for blast furnace use. Variations in chemical analysis can be expected from day to day, which makes efficient operation of a continuous process such as the blast furnace nearly an impossibility.

The Kaiser Steel Corp. realized even at the time the steel plant was first built that the ore in the west was not ideal so facilities for sizing, blending, and sulphur removal were installed for beneficiation of the ore prior to charging into the furnaces. During the past eight years, additional equipment has been added at the mine, and today, the corporation owns one of the most complete ore beneficiating plants in the United States.

The ore is crushed to −1 in. at the mine and then screened over ⅜-in. wet screens. The 1 x ⅜-in. fraction (referred to as coarse ore) is passed over magnetic drums to separate the magnetite ore from the hematite ore and the gangue. The magnetite ore goes directly to the coarse ore shipping pile while the hematite and gangue go to a heavy media separator in which the gangue is floated away from the ore. The hematite ore then joins the magnetite ore in the shipping pile. The −⅜-in. ore (referred to as fines) is washed over jigs and the fine clay and other gangue removed. The washed fines are then sent to a separate shipping pile. This concentrating of the ore normally results in upgrading to approximately 58 per cent Fe.

Inasmuch as the production of a blast furnace is increased about 25 tons, for each increase of 1 per cent in Fe content of the ore, an increase of Fe from 48 to 58 per cent will increase production on one furnace by 250 tons per day and for three furnaces, 750 tons per day. This is approximately one-half the production of one of the present furnaces, obtained with very little capital expense or operating labor. All steel companies are today striving to obtain the best grade ore for their furnaces, either by shipping in foreign ores or by beneficiating local ores.

The operations at the mine accomplish two necessary improvements to the ore, that of removing gangue, thus upgrading the Fe content, and also properly sizing the hard, dense ore so that the gases in the furnace can efficiently reduce it. These improvements result in savings in coke and limestone.

After beneficiation at the mine, there are still two detrimental qualities of the ore which must be overcome: variation in chemical analysis and the high sulphur content. Equipment is provided at the steel plant to handle these phases of the beneficiating program.

The coarse ore and fine ore are shipped in separate cars to the steel plant, where three blending beds (Figure 5) have been provided for each of the two sizes. Each bed is 555 ft long and will hold a maximum of 18,000 tons. A stacker travels the length of each bed, laying the ore down in thin layers as it travels back and forth. In this way, the ore from over 250 cars is blended. When the ore is sent to the furnaces, it is removed from the pile by a reclaimer which completes the blending by raking the ore from a cross section of the pile which is approximately perpendicular to the direction of bedding. To properly complete this blending, two beds must be active each day; one on which ore is being bedded, the other from which ore is being reclaimed.

Figure 5 — The blending piles at the Fontana plant. Crushing and screening equipment are housed in the buildings on the right. The two blended piles on the right contain coarse ore 1 x ⅜ in. for furnace feed. The two on the left contain ore fines, ⅜ in. x 80 mesh, roll scale, and flue dust blended for sinter plant feed. A corner of the sinter plant and the sinter stockpile show on the left side of the picture.

The coarse ore (1 x ⅜ in.) is sent directly to the furnace bins from the blending stockpiles, however, the fines (−⅜ in.) must be further treated. They cannot be charged directly into the furnace, inasmuch as a majority of them would be blown out of the furnace by the gas. To overcome this, the ore must be sintered prior to charging into the furnace. In this process, the ore is mixed with about 6 per cent coke fines and burnt on a traveling grate in a continuous layer about 12 in. thick. The air to complete the combustion is drawn through the bed by a suction fan. This causes the fines to fuse together into porous lumps which can be charged into the furnace without excessive dust loss. Fortunately for the Fontana operation, this sintering process also burns the sulphur out of the fines, and thus two beneficiating processes are completed by the sintering machine. By charging the furnaces with the proper proportions of low sulphur sinter along with the high sulphur coarse ore, the sulphur content of the hot metal can be maintained at a level acceptable to the basic open hearth operation.

This paper, has tried to answer a question which is asked many times, "What is the difference between Western and Eastern blast furnace practice?" The answer is merely "raw materials." The furnaces are essentially the same. No special furnace operating techniques are used in the West which are not used in the East. Raw materials and their beneficiation make the difference. However, as time passes, this difference will become less and less as the supply of good raw materials is exhausted in the East, and the available materials must be beneficiated in order to be used economically in the blast furnace. It is generally accepted by the steel industry that a blast furnace is too expensive a piece of equipment in which to charge anything but the very best raw materials economically available. All steel producers, including Kaiser Steel Corp., are aggressively searching for better raw materials and for better methods of beneficiating those that they have. ▲

Soaking Pits With a High

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THIS paper reviews the factors that influenced the type of soaking pit installation made at the Brier Hill Works, Youngstown Sheet and Tube Co. in March, 1957, and discusses its problems and performance during its first year of operation. The soaking pits in this plant service a 44-in. blooming mill which operates primarily in conjunction with a 35-in. intermediate mill and a 24-in. cross country mill to produce rounds for the seamless mills. Rounds of 11¼ to 5¼-in. diam are rolled directly from the ingot without reheating. For rolling rounds down to 3¼ in. diam, the blooms are reheated in a continuous, triple zone-fired furnace. Ingot heating quality is an important factor in over-all product yield.

The original heating installation in this mill consisted of eight rows of producer gas-fired regenerative pits. Each row of pits consisted of four holes, 6 ft-3 in. × 6 ft-3 in. × 6 ft-9 in. deep. In 1939 fuel firing was converted from producer gas to coke oven gas with natural gas make-up. In the intervening years the pit area has been increased by changing from four to two-hole batteries and by lengthening some pits at a sacrifice of checker area. In 1940 a circular pit was installed. In March, 1957, No. 7 and 8 rows of the small regenerative four-hole pits were replaced by two 3-hole rows of modern one-way, top-fired soaking pits with one metallic recuperator per row. This latest installation features a high velocity combustion system.

The reason for new soaking pits was a need for increased heating capacity to permit taking advantage of potential rolling capacity. Accordingly, a study was made to determine the type of installation that would provide maximum ingot holding capacity, give high-speed, quality heating and require a minimum of outage time for service and repairs.

LAYOUT OF NEW PITS

Figure 1 is a diagramatic layout of the existing soaking pit building. Some consideration was given to extending the building for adding new soaking pits, but this was found to be too costly, besides having the disadvantage of increasing the distance to the mill. It will also be noted that new pit layout possibilities were restricted by the ingot charging tracks on one side of the building and the mill ingot delivery tracks on the opposite side. This precluded consideration of everything but the island type of pit layout. It also dictated that for maximum possible pit length and cross-sectional area, the pit construction would have to be the one-way, top-fired design with the recuperator located away from the pit proper, i.e., in the lean-to bay. Ingot sizes used by this mill favored 3-hole rows of pits as indicated for No. 7 and 8 rows in Figure 1.

Each of the new 3-hole pits is 9 ft-0 in. wide × 18 ft-6 in. long on centerlines. Walls are cambered in 4½ in. on their sides and ends. It will be observed in Table I that this increased the pit ingot holding area of No. 7 and 8 rows from 208 to 470 sq ft per row effecting a gain of 126 per cent per row.

COKE BREEZE VS DRY BOTTOM CONSTRUCTION

The top-fired pit requires a minimum of 5 ft-6 in. space above the ingots for proper combustion. Normally this is obtained by raising the crane runway or by lowering the foundation level accordingly. The former was impossible with the existing building, and the latter would have meant a very costly expenditure for relocation of sewers and protection against possible backwash of water during high river levels. The

Figure 1 — Existing revamped layout of the Brier Hill blooming mill soaking pit building.

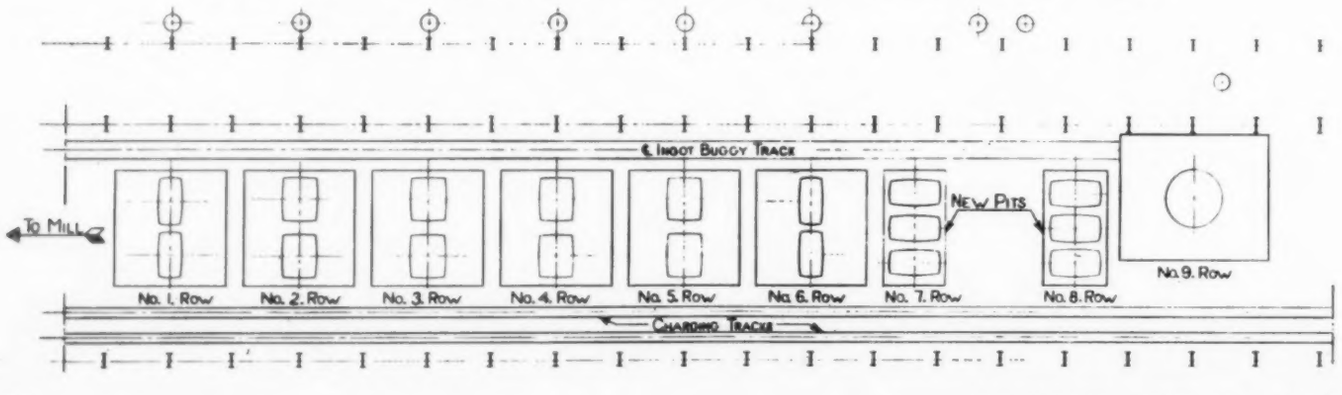


TABLE I
Comparative Ingot Holding Area—Brier Hill Blooming Mill Before and After New Pits

Row No.	No. of pits per row before	Type and size of pit after	Pit area—sq ft		Increase in pit area	
			Before	After	Sq ft	Per cent
1	2 Pits regenerative 7 ft-0 in. x 15 ft-11 in.	No change	208	208	No change	No change
2	2 Pits regenerative 13 ft-9 in. x 14 ft-9 in.	No change	384	384	No change	No change
3	2 Pits regenerative 13 ft-9 in. x 14 ft-9 in.	No change	384	384	No change	No change
4	2 Pits regenerative 13 ft-9 in. x 14 ft-9 in.	No change	384	384	No change	No change
5	2 Pits regenerative 13 ft-9 in. x 14 ft-9 in.	No change	384	384	No change	No change
6	2 Pits regenerative 7 ft-0 in. x 15 ft-11 in.	No change	208	208	No change	No change
7	2 Pits regenerative 7 ft-0 in. x 15 ft-11 in.	3 Pits recuperative 9 ft-0 in. x 18 ft-6 in.	208	470	262	126
8	2 Pits regenerative 7 ft-0 in. x 15 ft-11 in.	3 Pits recuperative 9 ft-0 in. x 18 ft-6 in.	208	470	262	126
9	1 Pit nonregenerative 20 ft-0 in. inside diam	No change	314	314	No change	No change
		Total shop	2682	3206	524	19.6

Velocity Combustion System

economic solution called for the elimination of the usual high basement construction needed for the dumping and handling of refuse with coke breeze bottom practice in favor of dry bottom construction with top removal of accumulated scale. This made it possible to design the pits with a depth of 15 ft-6 in. from top of curb tile to top of bottom brickwork. This depth will satisfactorily accommodate the 110 in. ingots proposed for the future.

The decision to use dry bottom construction and practice made it imperative that careful consideration be given to the combustion system and its control because of the effect of combustion on build-up of scale and cinder. Occasional excesses with coke breeze bottom practice can easily be remedied by dumping between charges, but with dry bottom practice the pit must be taken out of service for cleaning.

Soaking pit capacity is increased without expanding existing building by replacing two batteries of four small, gas-fired, regenerative pits with two batteries of three larger, one-way, top-fired, recuperative pits . . . . each battery has its own recuperator . . . . installation is operating satisfactorily with a minimum of maintenance the first year.

THE PROBLEM OF PROPER COMBUSTION

Previous experience in forcing production from top-fired pits using coke oven gas had shown some sacrifice in heating quality accompanied by a greater scale and cinder accumulation then could be economically tolerated with dry bottom practice. On the other hand, investigation of similar pits fired with low Btu mixtures of blast furnace gas and coke oven gas disclosed fast, quality heating with very little bottom build-up of scale and cinder. It was concluded that two factors were responsible for the better performance of the lower Btu fuels. The lower potential flame temperatures are less likely to overheat and burn steel, and the higher combustion gas volumes required higher circulating rates resulting in a more uniformly heated pit. Since blast furnace gas was not available it was necessary to simulate the heating conditions obtained from this low Btu gas with coke oven and natural gas.

It appeared that this could be accomplished to a large degree by providing adequate combustion space above the ingots and using a high velocity burner system that induces quicker combustion and provides better recirculation of tempered combustion gases back into the firing stream and throughout the pit.

The importance of kinetic energy for high-speed, quality heating was determined from a study of other types of furnaces. The deterrent, as far as soaking pits were concerned, had been largely the economic requirement for heat recovery from the waste gases and, until recently, the inability to provide preheated combustion air at adequate pressure to the burners to permit a high velocity burner design. There are now several successful pit installations.

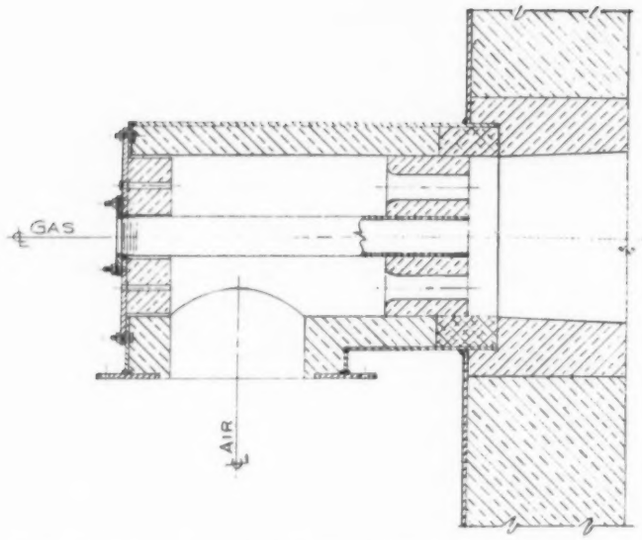


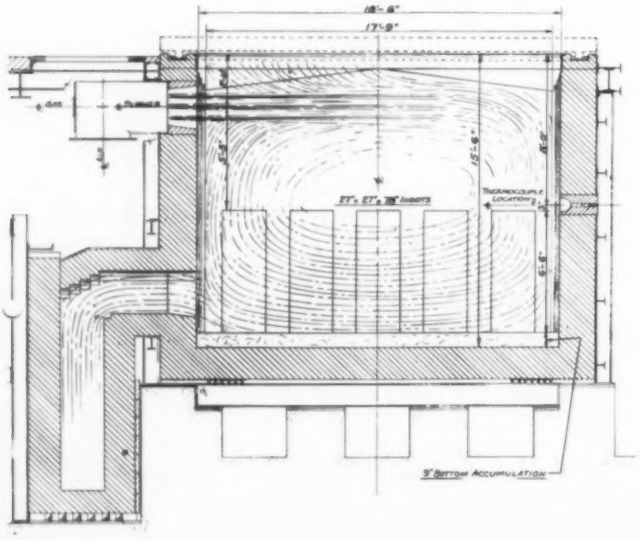
Figure 2 — Cross-sectional view of the high velocity soaking pit burner.

BURNER DESIGN AND APPLICATION

Figure 2 shows the burner design used in the new pits. The fuel used is either coke oven gas or natural gas. Provision is made for future installation of a fuel oil gun. The gas nozzle projects to the pit face of the refractory combustion air baffle. The number and size of holes in the baffle determine the distribution and velocity, respectively, of the air into the burner block. This burner requires 10 in. air pressure at the burner when firing at a rate of 17,500,000 Btu per hr compared with the slightly positive pressure available to the older conventional burners. Burner velocity at this rating is better than 300 fps. The net effect is that at all firing rates this burner has ten times the velocity and 100 times the kinetic energy of the older top-fired pits in the company's other plants.

Figure 3 is a longitudinal cross section of the pit giving the pit design dimensions and illustrating what happens to combustion and circulation of combustion gases within the pit when this burner is firing. It illustrates what is believed to be responsible for a more uniformly and faster heating pit.

Figure 3 — Vertical section view of soaking pit through burner port shows the flow of gas and air, combustion, and the flow of waste gases.



PIT REFRACTORIES

Each pit furnace wall is faced with 9-in. thick, burned, chrome magnesite brick to a height of approximately 30 in. from the bottom. They are backed up with high heat duty firebrick. The wall is racked from 9 in. at bottom to line of wall at 30 in. above bottom.

Pit side walls are constructed of 18 in. of sawed silica firestone. The interior, common walls between pits have a total thickness of 3 ft-6 in. of sawed silica firestone. All furnace walls adjacent to steel plate binding are insulated with 4 in. of insulating block in 2-in. layers with all joints broken.

The top of each pit furnace wall is built of special high heat duty fireclay curb tile properly shaped to form the trough to contain the granular silica material that forms the cover seal.

The waste gas ports are built of silica stone blocks, and the piers of super duty brick laid in high temperature cement. Both pier and lintel construction extends through the entire thickness of the furnace end wall.

The hearth of the pit is made up of a 4½ in. top course of chrome magnesite brick, 10 in. of high duty firebrick and 5 in. of insulating brick.

The furnace covers are the sand seal type and have flat suspended arch construction with a 9 in. depth of super duty brick covered with insulation. The covers for the two rows of 3-hole pits are handled by one cover carriage.

APPLICATION OF METALLIC RECUPERATORS

The need for preheated combustion air at higher than normal pressure made the use of metallic recuperators mandatory. The preferred arrangement would have been a separate metallic recuperator for each pit so that each pit is completely independent for service and maintenance. This was impossible because the island type pit layout is hemmed in by the ingot charging tracks on one side and the ingot delivery tracks on the opposite side, and by a confined lean-to bay. Therefore consideration was given to providing one recuperator for each row of pits. Available space made it necessary that the recuperator be as compact as possible. The importance of quick and easy maintenance resulted in the decision to install portable, flue-type recuperator units.

Figure 4 is a layout of the pits and recuperators. The two rows of pits were arranged for opposite hand firing primarily to provide space for easier handling of the ingots in and out of the pits.

Figure 5 shows a vertical section through the waste gas flues. It illustrates the simplicity of the installation.

Figure 6 shows the arrangement of a single recuperator unit in the flue. The recuperator for each row of pits is comprised of three recuperator units set up in tandem. An overhead monorail crane makes it possible to quickly pull out and replace a recuperator unit when necessary.

Figure 7 shows a single recuperator unit, which weighs about 15,000 lb complete.

Figure 8 shows a recuperator element. The elements are 28 to 30 chrome alloy with no nickel designed for economical operation with waste gas temperatures up to 1850 F.

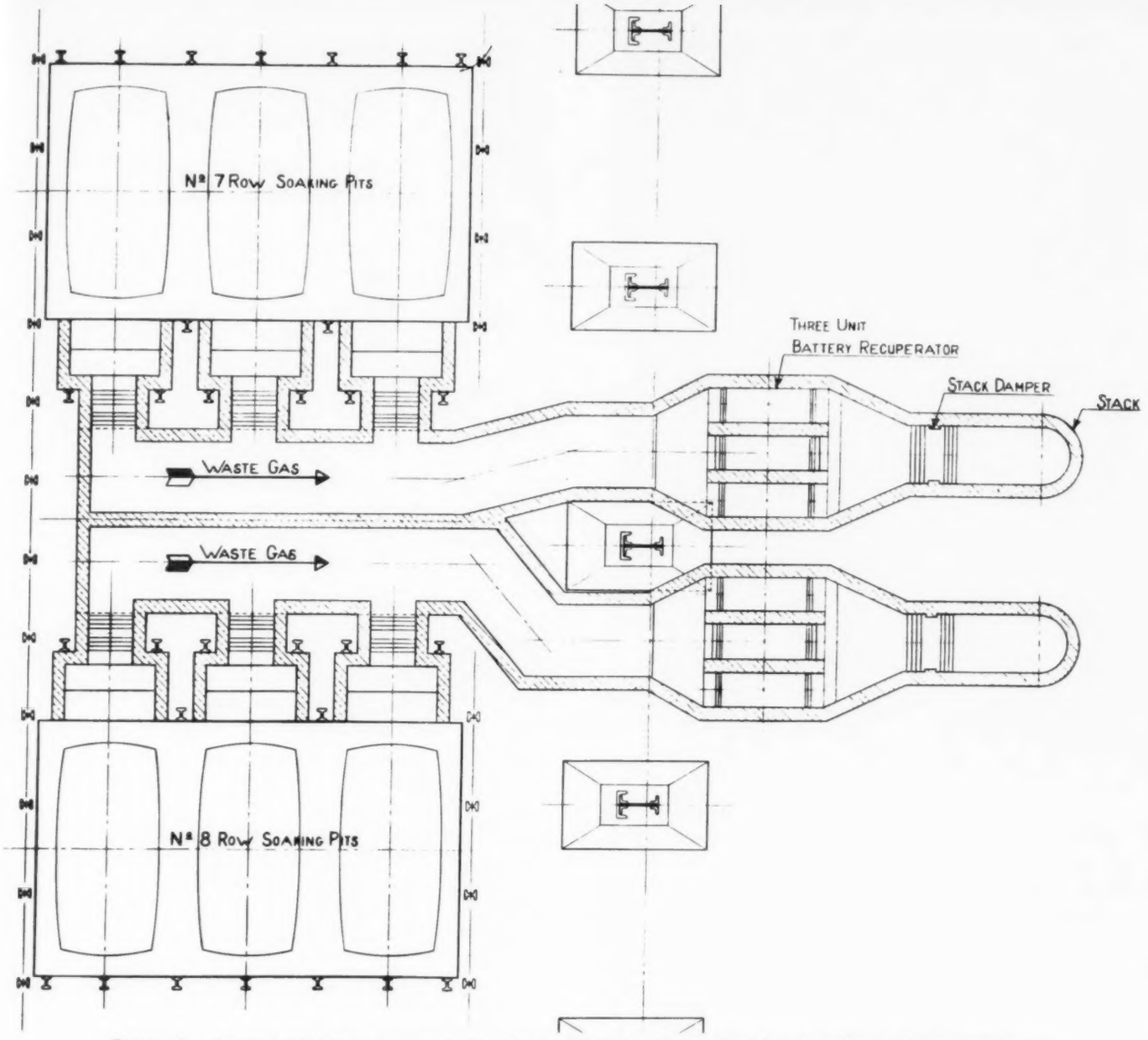
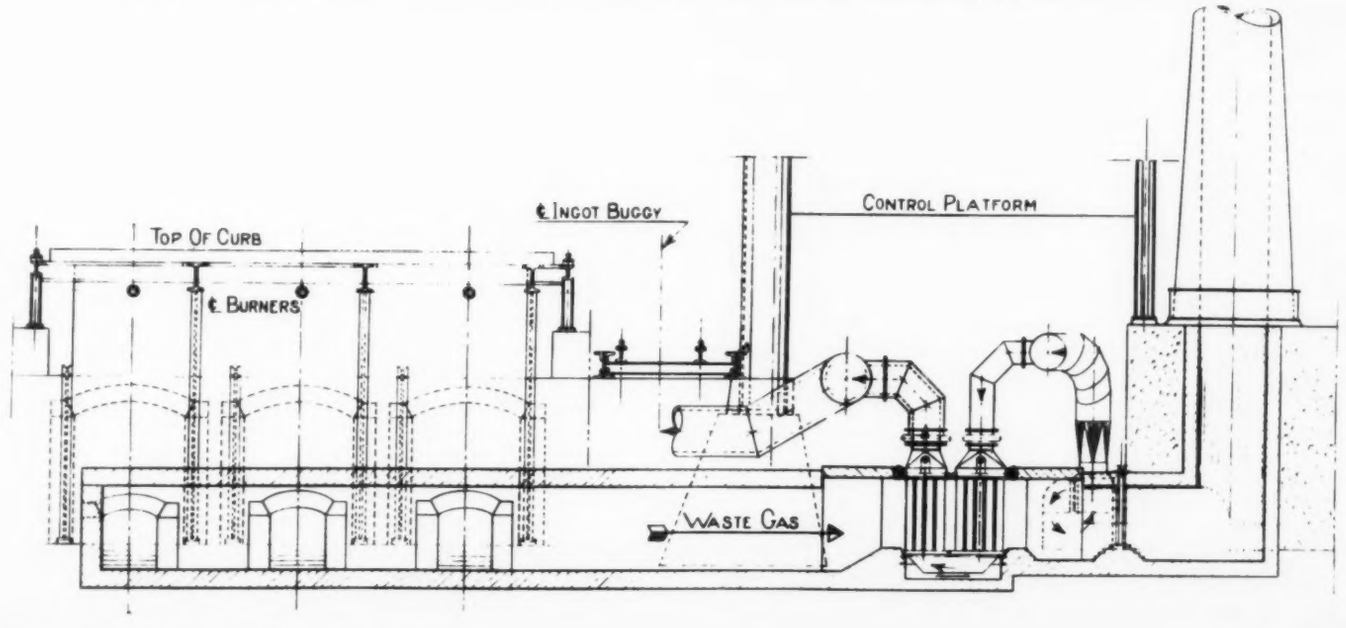


Figure 4 — Layout of pits and recuperators for opposite hand firing makes handling of ingots easier.

Figure 5 — Vertical section view through the waste gas flue illustrates the simplicity of the installation.



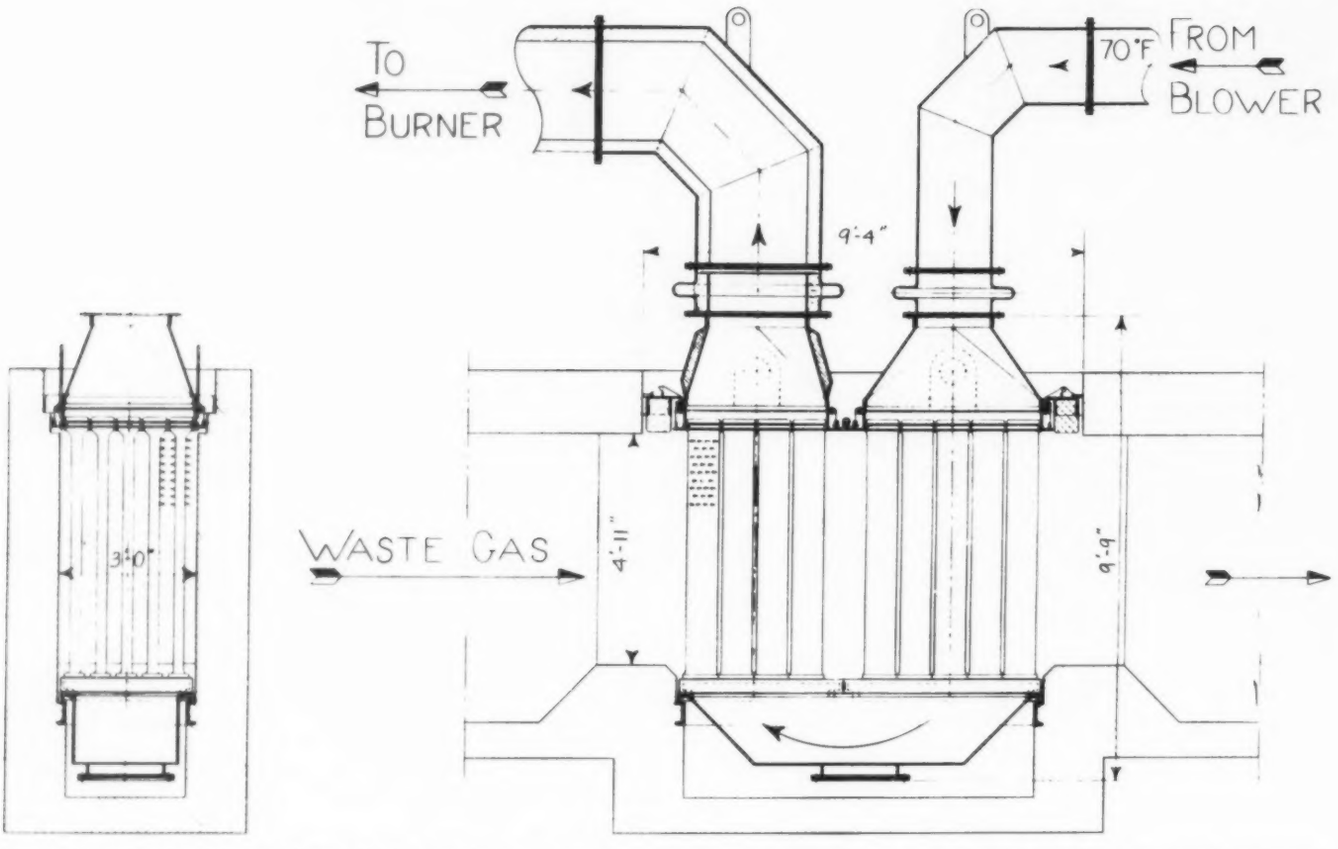


Figure 6 — Arrangement of one of the single three-unit recuperators provides for easy removal by the overhead monorail crane.

Table II gives the design specification for the recuperators and the actual operating data for high and low firing rates. It will be noted that the temperature of waste gas to the recuperators is considerably lower than anticipated, but that preheated air temperatures are only slightly less, reflecting good recuperator efficiency. Loss of heat through the water-cooled, refractory-lined individual pit dampers is responsible for dropping the waste gas temperatures about 150 F.

In day-in, day-out ups and downs of operation, the temperature of waste gas to the recuperator varies from 1600 to 1730 F resulting in air temperatures of 880 to 940 F. Waste gas temperatures average about 1710 F and air temperatures about 900 F. It is believed that elimination of the water-cooled pit dampers would raise average air temperatures to about 935 F.

INSTRUMENTATION

It developed that two different but related automatic control systems would be required—one for each soaking pit and one for each row of pits. Instruments and controls for the pits proper include the conventional application for soaking pits as indicated in Figure 9. The only significant difference is the addition of a maximum fuel input control that limits the amount of fuel which the pit temperature control can bring in. This is considered helpful in meeting varied operating conditions.

Figure 10 shows the panel layout and instrumentation common to each row of pits as distinguished from the pits proper. Provided for the protection of the recuperator during normal pit operation are a maximum waste gas temperature control that limits the temperature of the waste gas entering the recuperator to 1800 F, and a preheated air bleeder control that assures a minimum of 25 per cent air flow through the recuperator at all times. In addition there are automatic controls for maintaining a constant pressure of combustion air after the recuperator, a temperature control for adjusting the individual pit air-gas ratio control for combustion air temperature variation, and a stack damper regulator for holding a constant draft in the waste gas flue. All controls are pneumatically operated and are tied in for automatic shutdown of pits in case of power failure, combustion air failure, instrument air failure, or excessive waste gas temperature in the recuperator.

PIT OPERATING PROCEDURE

The heater is primarily concerned with the adjustment of pit temperature control. He normally operates the pit at 2400 F throughout the cycle. If pushed for production he may set the control for the allowed maximum of 2420 F at the beginning of the cycle and reduce after the steel reaches temperature. When a pit is idle, he drops the temperature to 2300 F to avoid overheating the bottom. On mill-down turns he lowers the temperature to 2200 F and raises it to 2400 F about four hours before mill rolling time.

The only other control that the heater is required to adjust is that governing maximum fuel input. At the start of the cycle he sets this control to 17,500,000 Btu per hr. Each time before raising the cover to check the condition of steel in the pit, he lowers the fuel input setting to correspond to the prevailing flow. This

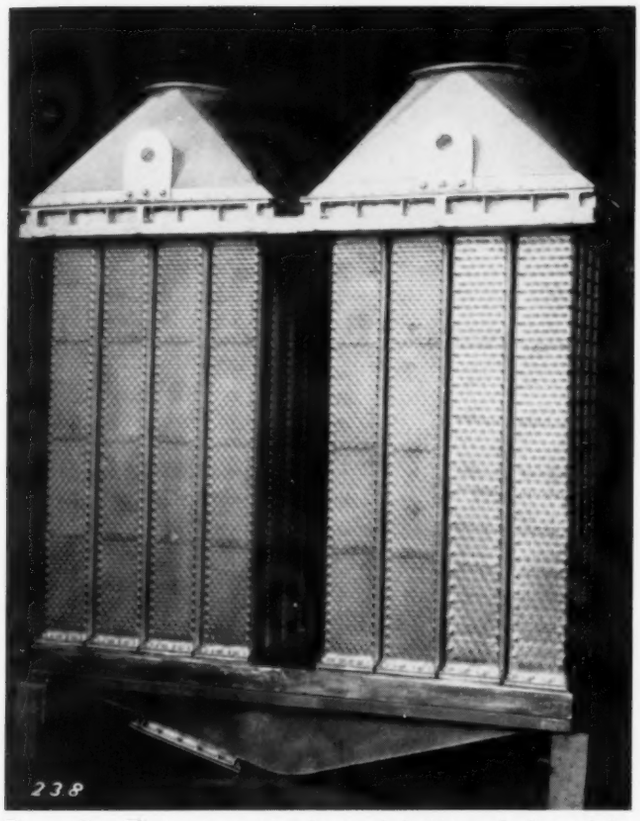


Figure 7 — The recuperator for each battery of pits weighs 15,000 lb.

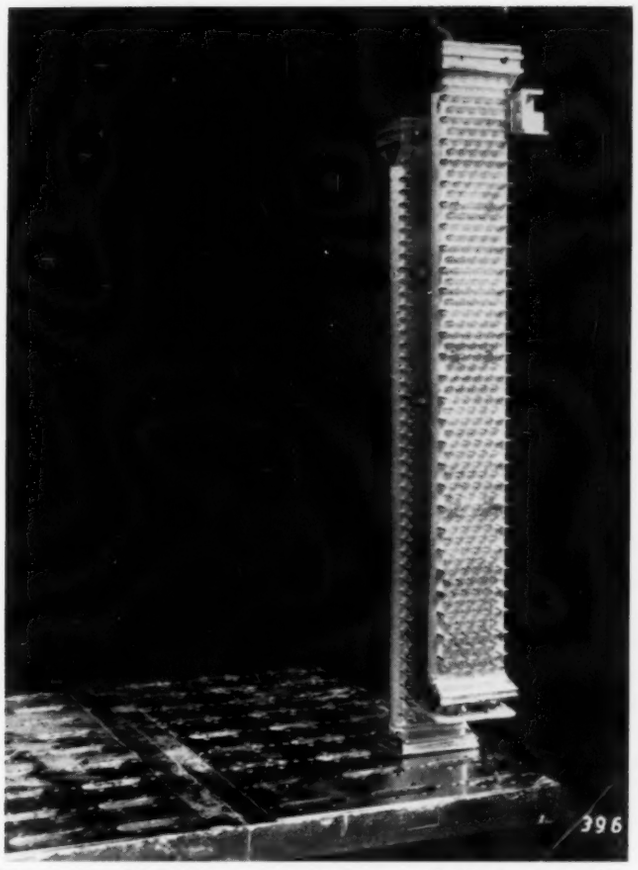


Figure 8 — Recuperator elements are 28-30 chrome with nickel alloy and are designed for economical operation with waste gas temperatures of 1850 F.

limits maximum fuel firing after the cover is returned. If he did not do this, the temperature control would bring on maximum fuel because of the temporarily lower pit temperature. The heater also uses this control to advantage under other conditions when steel will not be needed regularly, when pits are empty because of lack of steel, or when a pit is being brought back to operating temperature after a long shutdown.

The pits are never operated on manual control. The heater is instructed to shut down the pit and call an instrument repairman when the automatic control is not functioning properly. On night turns this means calling out a man. This happened on two occasions in the past year, and the total lost time in each case amounted to only two hours on the particular pit. An instrument repairman checks all charts daily and reviews them with the operating department. In this way, any out-of-line conditions are found and corrected almost immediately.

PROBLEMS

In all new plant installations, problems arise that have to be worked out by experience. Fortunately, in this case, there have been only two.

The first was a failure of a combustion air control valve on one pit that resulted in carry-over of raw gas and burn-out of the first row of the four row inlet bank of the recuperator. The waste gas temperature control

TABLE II
Recuperator Operating Data

Design specifications		Actual performance	
		High flow	Low flow
Total fuel input into one three-hole row, million Btu per hr	48.0	40.15	11.55
Quantity of fuel, cfhr	43,600	36,500	10,500
Excess combustion air rate, per cent	10	12	30
Waste gas volume, cfm	9,700	7,720	2,550
Waste gas plus dilution air, cfm	11,300	...	...
Waste gas temperature before dilution, F	2,100	1,800	1,710
Waste gas temperature entry recuperator, F	1,850	1,800	1,710
Waste gas temperature exit recuperator, F	1,265	1,100	930
Air volume through recuperator, cfm	8,280	7,060	2,500
Required combustion air, cfm	8,280	7,060	2,360
Bleed air, cfm	...	...	140
Air temperature entry recuperator, F	70	70	70
Air temperature exit recuperator, F	950	900	920
Effective heat transfer million Btu per hr	8.29	6.65	2.42
Pressure loss waste gas side, in. water column	0.34	0.2	0.05
Pressure loss, air side, in. water column	3.4	2.6	0.6
Fuel: Natural gas, 1100 Btu per Cu ft			

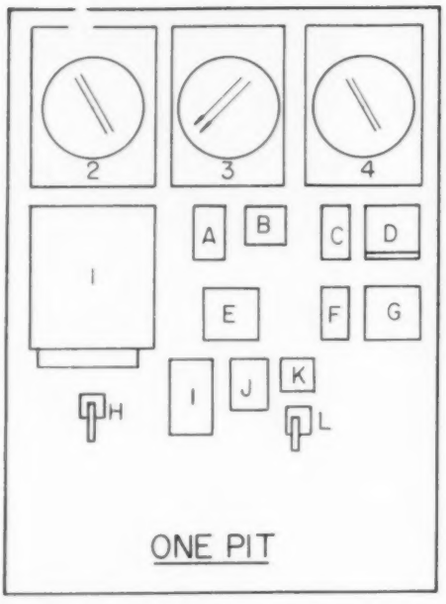


Figure 9 — The individual pit control panels have the instruments found in conventional soaking pit applications plus a maximum fuel control.

STATIONS AND INDICATORS

A. FIRING SET POINT
B. LIMIT CUT OUT
C. PIT PRESSURE SET POINT

RECORDERS AND INDICATORS

1. PIT TEMPERATURE RECORDER. TEMPERATURE SET POINT INDICATOR AND TEMPERATURE CONTROLLER.
2. COMPENSATED AIR FLOW AND GAS FLOW RECORDER.
3. FUEL SET POINT AND GAS FLOW INDICATOR.
4. PIT PRESSURE AND GAS FLOW RECORDER.

D. FURNACE PRESSURE DAMPER RELAY
E. AIR TEMPERATURE COMPENSATOR RELAY
F. AIR/FUEL RATIO SETTER
G. COMBUSTION AIR VALVE RELAY
H. SELECTOR SWITCH
I. FUEL SHUT-OFF TIMER
J. PUSHBUTTONS (2)
K. LIGHT
L. SELECTOR SWITCH

for protecting the recuperator against overheating brought on dilution air that normally would have held the waste gas temperature to a maximum of 1800 F. In this case though, the supplied air resulted in combustion and raised the waste gas temperature above 2200 F, the pyrometer maximum. The condition of waste gas flue brickwork indicated the temperature exceeded 2600 F. To prevent this from happening again the control system was revised to include an alarm and complete shutoff of the gas when the waste gas temperature entering the recuperator reaches 1850 F.

The second problem involves the maintenance of individual pit dampers. These are of the water-cooled, refractory-lined, rotary design—the only type of damper which could be installed in the space available. These dampers work very well, but cramped conditions make their removal a major operation. The use of raw Mahoning River water requires periodic removal of the dampers for cleaning to prevent fouling. On this account, consideration is being given to eliminating the individual dampers and using the main flue damper for battery or row draft control. Experiments indicate that

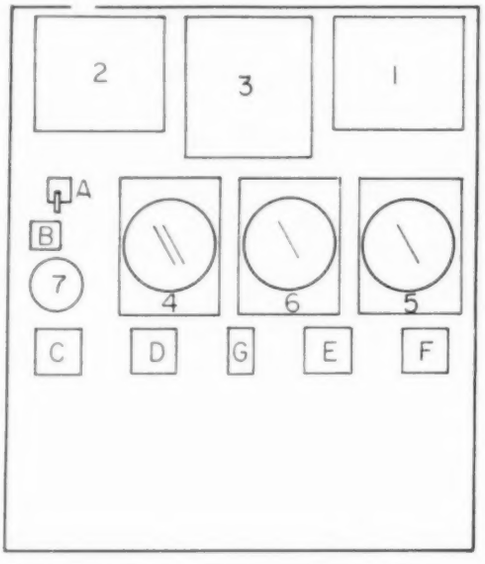


Figure 10 — The battery control panel includes protection for its recuperator as well as automatic controls and regulators for the pressures and temperatures.

STATIONS AND INDICATORS

A. THERMOCOUPLE SELECTOR
B. ORIFICE SELECTOR (COKE OVEN OR NATURAL GAS)

RECORDERS AND INDICATORS

1. PIT TEMPERATURE RECORDER (6 POINT)
2. RECUPERATOR TEMPERATURE RECORDER (8 POINT)
3. WASTE GAS DILUTION AIR CONTROL
4. INLET AIR FLOW AND BLEED AIR RECORDER
5. GAS PRESSURE RECORDER
6. FLUE DRAFT RECORDER
7. COMBUSTION AIR PRESSURE GAUGE

C. COMBUSTION AIR VALVE AUTO/MANUAL STATION
D. RECUPERATOR AIR BLEED VALVE AUTO/MANUAL STATION
E. BATTERY FLUE DAMPER AUTO/MANUAL STATION
F. GAS PRESSURE VALVE AUTO/MANUAL STATION
G. PUSHBUTTON STATION

this can be done without sacrifice of heating production or quality. It will result in more heat in the waste gases going to the recuperator and a higher preheat of combustion air.

PERFORMANCE

The new pits have done a consistent job of quality heating. Even when held at temperature for prolonged periods, the scale on the ingots has not appreciably increased. In six months operation the pit bottoms only build up about 12 in. reflecting close control of combustion and the absence of ingot washing.

Mill schedules during the past year have not afforded the opportunity to operate these pits at their production potential. A large number of standby turns has made good operating turn production rates but low over-all heating rates. However, it has been determined that these pits are capable of fast heating. For example, 68 net tons of charge of twelve 23 × 26-in. ingots or ten 27 × 27-in. ingots ranging in track times from two to four hr can be made ready to roll in a net heating time (finish charge to ready draw) of two hr-15 min to four hr-45 min respectively.

Fuel consumption has also suffered from the number of standby turns and shutdown turns. A study of performance for periods of around-the-clock mill scheduling indicates that the monthly figure for such an operation would average about 725,000 Btu per net ton.

The use of dry bottom practice is considered a success. Because time has been available, bottoms have been cleaned every six months, though build-up amounted to only 12 in. Space has been provided for 18 in. build-up.

In concluding, the first year's operation of these pits has been practically trouble free with a minimum of required maintenance. ▲

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Electrical Advances

Can Reduce Installed Costs

. . . . many of the new products on the market today were originally developed in an effort to reduce costs . . . . willingness by steel mill people to apply these new products to proposed installations will result in dollars saved . . . .

by E. E Vonada,
Product and Application Specialist,
Reliance Electric and Engineering Co.,
Cleveland, Ohio

BUSINESS executives take great pride in watching their company flourish and grow. This is their desire. They are continually seeking ways and means of producing a better product more economically. Cost studies are conducted continuously along these lines, and the question "how much is it going to cost?" must be answered. After comparing projected costs against projected benefits, the executives determine whether the proposed project should be consummated or abandoned.

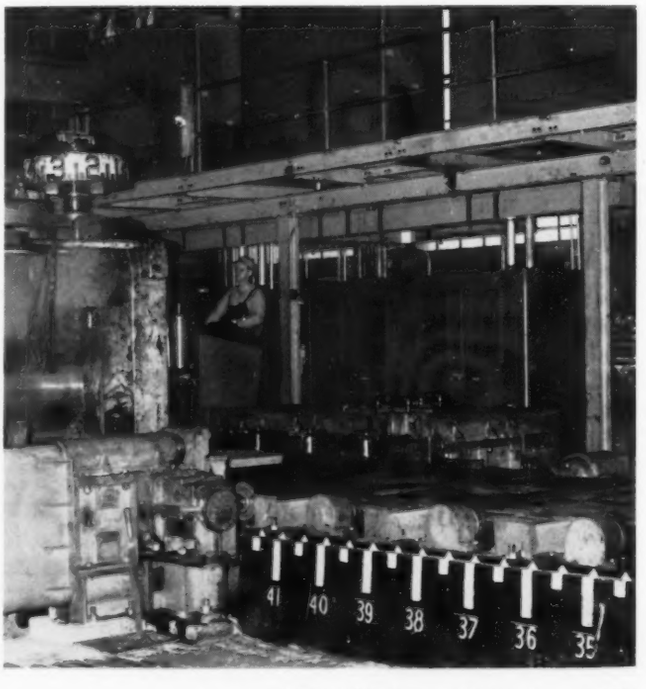
Smaller and newer plants invariably arrive at lower installed cost figures than those of older and larger plants for duplicate projects. Some of the factors contributing to this condition are resistance to change, labor problems, lack of co-operation between divisions or departments, and outmoded standards.

Amplifying these factors, let us first consider resistance to change. Everyone has a natural tendency to increase his resistance to change as he gets older. He is less willing to take chances on new devices, methods, and techniques. We completely ignore the fact that the new devices, methods, or techniques were developed primarily in the interests of cost reduction. As a consequence, high material cost, combined with the ever increasing installation cost, often results in shelved projects. In contrast, had the new developments been accepted, a lower material cost, combined with lower installation cost, could conceivably have resulted in the total costs being within budgetary limits thus enabling the project to proceed. For example, pickle lines of the older type, with a single scalebreaker and long pickle tank sections, are being replaced by the newer type that has an additional secondary scalebreaker or mechanical scale removing means but shorter pickling sections. Another example can be found in the wire drawing industry where the separate motor-generator set and control room has given way to the integration of the motor-generator set and control with the machine.

The labor problem is introduced here only because production, construction, and maintenance labor costs become an important item in arriving at an over-all, installed cost. In many cases, small companies and new plants have labor cost advantages over the larger companies and older plants.

As to the lack of co-operation, the "finger pointing" atmosphere, existing in some large and small plants alike, automatically results in higher installed costs. In this atmosphere engineering and, in many cases, maintenance divisions are repeatedly nailed to the cross because of failure of equipment resulting in loss of

Figure 1 — The cost of conduit runs can be reduced by using adjustable voltage packages that can be installed on the mill floor next to the machinery to which it supplies power. The package drive shown is installed next to a rebuilt line.



production. The production division has its goals set so high that even minor production stoppages are intolerable. The engineering and maintenance divisions then become a convenient alibi—engineering because they did not provide infallible equipment and maintenance because of questionable maintenance practices. As a consequence, when cost estimates are prepared for new projects, the engineering groups are going to specify the most rugged and most expensive equipment they can find on the market. Further, they are going to go to extremes in arriving at installation arrangements and methods in an effort to minimize possible future criticism. As a result, both equipment and installation costs will be of such magnitude as to cause the entire project to be rejected.

Now take a look at the plant where the divisions or departments work harmoniously together. There is no "finger pointing" because all divisions are in harmony as a result of all having had an equal voice in selecting and specifying equipment for the proposed new project. Under this condition, quality of product and installation may be sacrificed to a limited extent in order to arrive at or below an accepted installed cost estimate. By such action the proposed project can be consummated thereby enabling the company to grow and prosper.

For these reasons, many of the older and larger companies are purchasing and installing equipment in accordance with specification standards established in the 1930 depression years. At that time equipment and installation costs were about one-third of the present day costs. Even so, in those days installation costs represented 30 to 40 per cent of the total. Today, installations made according to the same standards represent 40 to 50 per cent of the total depending on the complexity and dimensions of the process line.

It is true that installations made under these conditions resulted in a thing of beauty to engineers and maintenance men alike. The nicely painted, well lighted and ventilated room housing motor-generator sets and control panels facilitate maintenance, but does not necessarily reduce the required number of maintenance men.

Divorcing motor and generator field leads from respective armature power leads, and utilizing metal-sheathed cable in the separate conduit would theoretically assure absolute continuity of service. Unfortunately, this has not been the case because of the sheath rupturing during installation or later from electrolytic corrosion.

These specifications also contain many expensive control features such as positive and negative line contactors for each motor, positive and negative field loss relays for each motor field, instantaneous and time-delay overload relays. All of these are holdovers from the old constant potential days. In addition, positive and negative line contactors and overloads are required for each generator, and all contactors and relays must be mounted on slate with asbestos insulated control wiring. The high installed cost estimates that result from conforming to these extremely high quality specifications often result in shelved projects.

What do some of the smaller companies and the more progressive larger companies accept to obtain substantially lower installed cost estimates that permit them to proceed with the purchase and installation of much needed projects?

In the past ten years, a-c low tension power centers, which provide a packaged transformer and distribution center that can be installed near the area load, have found increased acceptance. Prewired centers and the resultant shorter secondary circuits result in lower installed cost. Similarly, a-c motor control centers have become an important item in reducing installed cost.

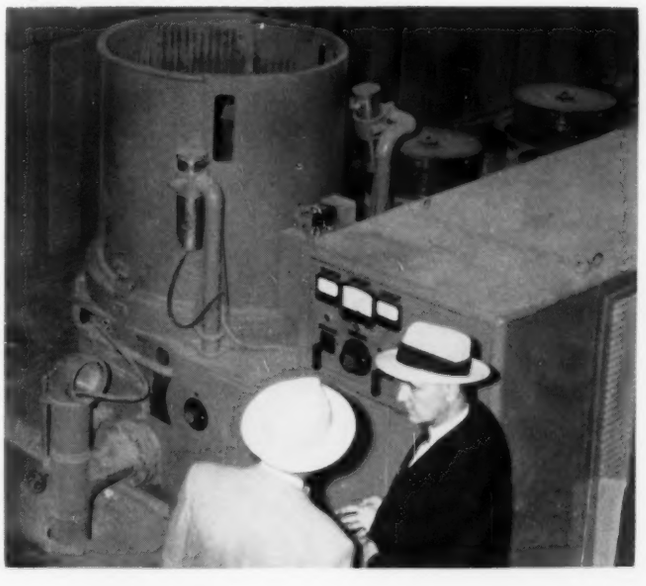
The last five years have seen rapid growth in the use of low tension, a-c, distribution ducts. Also, jacketed synthetic rubber–multi-conductor cables and cable trays have replaced metal-covered cable and conduit for d-c power and control circuits.

The use of individual generator drive systems for processing lines has increased. One important feature that has influenced the growth of this trend has been the fact that motor-generator set groupings can be arranged close to the drive motors, thereby limiting the length of conduit and cable runs which results in decreased installation cost. Because motor-generator sets are mounted on the mill floor close to the drive unit, motor-generator and control rooms are eliminated. The control is built in NEMA 1 enclosures and set close to the motor-generator sets. This is another important cost reduction.

In the same period of time, we have seen an amazingly rapid increase in the use of packaged drive systems. The desire for reducing installed cost has been the impetus behind this amazing growth. Cost reduction results from the motor-generator sets and control being housed in a single cabinet that is factory wired and tested before shipment to the site of installation. These force-ventilated, filtered packages are installed close to the drive motor thereby minimizing conduit and cable runs. Another important feature besides price reduction for this type of construction is the short time and minimum expense involved in moving this type of equipment.

A recent installed cost estimate for a major processing line showed the application of packaged drives in place of the conventional room housing the motor-

Figure 2 — To save space and dollars this power generating equipment and control are packaged with their drive motors in cabinets that are combined with the modern high-speed wire drawing machines.



generator set and control panels resulted in a $400,000 saving in favor of the packaged drive. This represented approximately a 15 per cent installed cost reduction, a very substantial saving.

Within the past few years adjustable voltage wiring materials have undergone a revolution. The conventional solid conductor, asbestos-insulated control wire has been replaced by stranded plastic insulated wire held in place by wiring channels. Cost reduction will obviously result from this type of construction because of the reduced time and material costs. This is a step in the right direction because the newer materials and techniques are used. Channel wiring is excellent and has found complete acceptance in the automotive industry.

Floating worm gearmotors were developed primarily as a cost reducing item for driving individual rolls on slow speed tables.

Another important item that reduces installed cost is the utilization of fused, polarized four-pole plugs to protect d-c helper and roll table drive motors in ratings up to 5 hp. With these plugs, the two armature leads are fused, and a thyrite discharge resistor is mounted in the conduit box and connected across the field terminals, to provide the necessary means for field discharge should the plug be removed with excitation on the motor field. Material-wise, this is a low cost item when compared to the more conventional small motor protective schemes that include knife switch, field loss relay, field discharge resistor, armature contactor, and overload relay. A very substantial installation cost reduction is realized when comparing these two protective systems. With individual protective panels, individual conduit and cable runs are normally made between the control panel and the motor, whereas the fused plug protective system requires only a single conduit to carry common armature and field leads to all motors operated as a group.

Figure 3 — The application of floating-worm gearmotors to these individual rolls on a hot mill table reduced cost by sliminating a line shaft and bevel gears.

These cost reducing items are significant but certainly not complete. Similarly, the following present and future cost saving suggestions are incomplete.

WHAT IS NEW?

A new constant potential d-c control panel utilizing sheet steel panels on which is mounted front-connected relays and back-connected contactors with insulating bushings is being employed between the contactor electrical live parts and the steel panel.

A new adjustable-voltage control panel construction approach incorporates a combination of steel and slate or ebony asbestos panel materials. All motor field protective and commutating devices and all armature circuit control devices are mounted on slate or ebony asbestos panel sections and are rear-connected. Control functional and interlocking relays are mounted on steel panel sections and are front-connected.

A move away from the cumbersome mill-type control relay is becoming almost mandatory as the move toward complete automation progresses. In many cases, the mill-type relay operating time is so great that its use is impractical for many cyclical operations. Futhermore, it would in short order beat itself to pieces if frequent operation were necessary. The relays on these new control panels have exceeded the 10,000,000 operation minimum requirement of the automotive industry and have contacts designed to operate reliably in regulator and control circuits. These new control panels are designed to meet Class A factory assembled, open Class C, and NEMA I and IA enclosed mechanical standards.

The packaged drive idea is being extended to include motor-generator sets and control for larger horsepowers and for combining multiple motor-generator sets and control panels into a single prefabricated steel building or "lean-to." Lighting and ventilation provisions are made as part of the fabrication. For the lean-to type construction motor-generator sets and control are all assembled and factory wired in the building, and shipment is made as a complete package. Where separate buildings are required, the motor-generator sets and control are designed to facilitate easy assembly and interwiring in the field.

Rectifiers, both mercury-pool type and silicon are becoming more important. They offer reliability, space and weight advantages on unit or multiple-motor drive systems where regenerative braking slowdown is not a necessity. Europeans are years ahead in rectifier development and application. Their extensive use is a pretty reliable indication that they provide a relatively low installed cost item. They are using phase inverted rectifier systems on reversing drives at prices competitive with or below equivalent motor-generator set and control prices. We, in this country, have not been able to attain this price advantage.

More than ever, millions of dollars are being spent each year for new product research and development. All new products are subjected to rugged laboratory and field tests before they are marketed. Because many of these products were conceived with cost reduction as the objective, inclusion of them in proposed systems will lead to a reduced estimate of over-all cost. Thus willingness to accept new ideas will save money.

Discussion

PRESENTED BY

T. S. NOVAK, Superintendent Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

G. L. BERRY, Chief Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

A. S. URANO, Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

E. H. BROWNING, Manager, Metal Working Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

E. B. FITZGERALD, Manager, Systems Control Sales Div., Cutler-Hammer, Inc., Milwaukee, Wis.

G. M. BAUGHMAN, Sales Engineer, The Wean Engineering Co. Inc., Warren, Ohio

T. S. Novak: Mr. Vonada stated that the steel mill electrical people resist changes and are not willing to take a chance on a new device, a new method, or perhaps a new technique. In a fashion this may be true because, in many instances, it is the steel man and not the design engineer who is called into the plant in the middle of the night when the new, superior, failproof device fails. Often it is at this time that the steel man realizes that one needs special tools to make repairs, or needs an entire assembly because one small part failed, and that the design engineer had made little or no effort to be helpful to the maintenance man. It is true also that the majority of the new equipment and methods do not give trouble, but those that did leave us with an impression that tends to make us resist changes in equipment and methods. However, if a new device or method has any merit, the steel electrical man will certainly recognize and use it.

Figure 4 — The opened doors of this cabinet for a high-speed wire drawing machine show its drive motor at the left and its motor-generator set at the right, built in to conserve space. The motor-generator set rolls out on a track for convenient servicing.

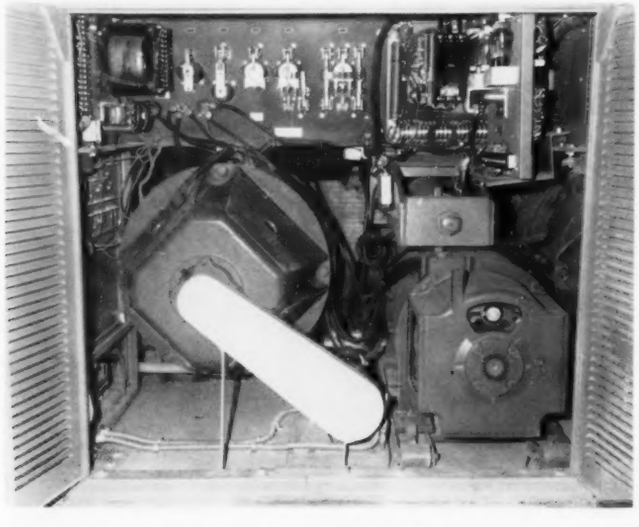


Figure 5 — The four-pronged plug shown above provides the utmost in convenience when servicing the motor. This plug is fused to protect the motor against overload.

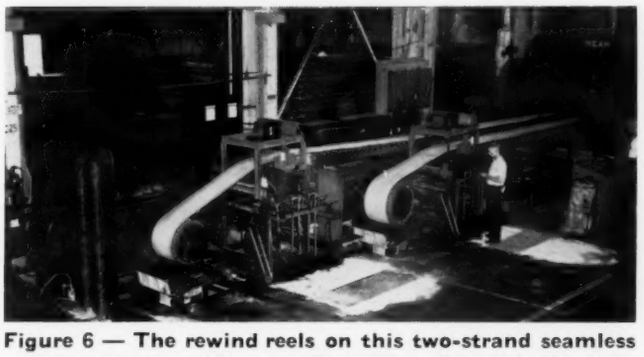


Figure 6 — The rewind reels on this two-strand seamless steel pickling line at Superior Steel Corp., Carnegie, Pa., have their power and control cabinets in close proximity to them (left of reel drive motors). This reduced installation costs by eliminating the cost of a separate generator room. Also, the length of conduit runs was reduced.

Mr. Vonada also stated that many steel people still require that many outmoded standards be satisfied, and that adds considerably to the cost of a new installation. I would not say that a lot of the steel plant standards are outmoded.

Does the electrical manufacturer not realize that these so-called standards are the result of some costly failure caused by the lack of adequate protection for devices in a particular control installation? Has the electrical manufacturer made an honest effort to help the steel man with his problems? If so, the manufacturer should

realize the reason for the request for these apparently outmoded standards.

We do not deviate too much from the manufacturers' standards. However, we do not criticize other steel plant standards because we do not know their problems.

The steel plant electrical people look at every new electrical device with a skeptical eye—that someday it will fail whether by natural use, by abuse, or by accident. When the device fails, they want the least damage possible. They are willing to spend a dollar for the installation of new equipment to save $10 in the future.

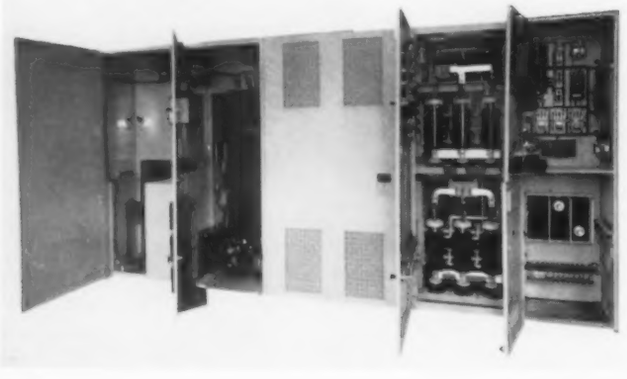
It was mentioned that some steel people prefer that field and armature leads be put in separate conduits. On main drive equipment we prefer to have the field leads isolated from our 600-v system. Through error this was not carried out on a four-stand sheet mill. Approximately seven years after it was placed in operation, we had a wire failure that cost us approximately $20,000 after the damage and mill production loss were accounted for. Compare this figure with the $500 we save on the installation cost. No one can challenge the fact that it is a good investment to spend $500 to save $20,000 in the future. Incidentally, I can say that this standard was established because we have had similar trouble in the past.

G. L. Berry: As our units become more complicated and the controls more elaborate, we must, more than ever before, relate our engineering designs to construction. The use of broader instrumentation and more complex automation devices simply do not lend themselves to the type of maintenance and field work being carried out today. The progress in package controls is good, but much more needs to be done before any substantial amount of the complexity of the work can be eliminated.

We have many new tools. Today, there are tuned frequency, pulsed circuitry, miniature rectifiers and many other devices that can be used to simplify our complicated electrical system.

A. S. Urano: I would like to emphasize one point. For large hot and cold rolling mills and continuous processing lines, reduced costs should not be obtained by sacrificing electrical features that would protect against prolonged downtime. To the steel industry, a continuous flow of finished products out the back door means profit. Any interruption, such as an electrical failure, can be costly.

Figure 7 — This typical 250-v, metal-enclosed, constant potential rectifier has replaced motor-generator sets in many a-c, d-c conversion applications.



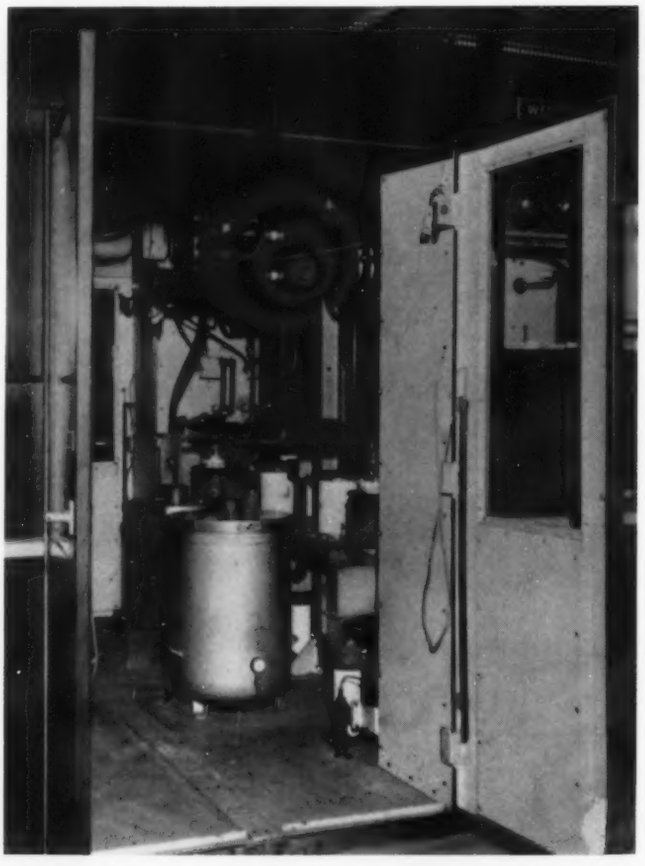
Fortunately, electrical advances are in the direction of making the electric equipment not only easier and less expensive to install but also its components and circuits more reliable and longer lived. Therefore it is not necessary to sacrifice quality for economy.

Today in the steel industry "packaging" and "static power" are magic words. Both can help materially to reduce installation time and costs. For example, we are building electric equipment for several, multi-zone, continuous process lines with packaged d-c static power supplies using saturable reactors and high current silicon rectifiers. These drives can be properly applied even in some cases where regenerative slowdown is required.

E. H. Browning: The author indicated in his closing paragraph that many millions of dollars are spent each year in industry for research and development. All of these dollars spent to improve equipment results in less cost to the equipment user for new equipment, its installation and maintenance, and improves the user's product quality and increases his productivity.

Figure 7 shows a 250-v, metal enclosed, constant potential rectifier such as the ones used for shop supplies. Twenty years ago the motor-generator set held a monopoly in a-c, d-c conversion, but today the rectifier has taken over the 350 to 3000-kw range. The reasons are its higher efficiency, less maintenance and lower installation costs. The selling price of a rectifier at this voltage rating is more than that of a motor-generator set with the same rating. However, its installa-

Figure 8 — Through research and development, the cost of radio-frequency generators, such as this one supplying induction reflow power for melting the tin coating on steel strip processed in high-speed electrolytic tinning lines, has been reduced in recent years.



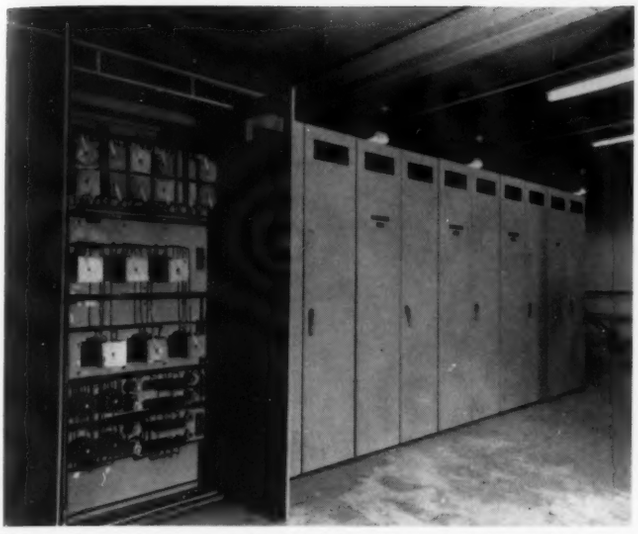


Figure 9 — These metal-enclosed, magnetic amplifier voltage regulators for a four-stand cold reduction mill require a minimum of interconnections between equipments resulting in dollars saved.

Figure 10 — Recent reductions in the prices of reliable transistors have resulted in price reductions for equipment such as this card programed, digital controller for automatically controlling the operation of a reversing roughing mill.

tion costs are less. No special foundation is needed—just a reasonably level floor strong enough to support the static weight of the equipment. Alinement costs are eliminated, and the packaged, or close-coupled arrangement further contributes to the savings. In the first compartment starting at the left are the incoming a-c line and auxiliary transformer. Next in line are the a-c circuit breaker, the dry type rectifier transformer, the ignitron rectifier, and finally the d-c circuit breaker and control.

Figure 8 illustrates a view of a radio-frequency generator used to supply induction reflow power for melting the tin coating on steel strip processed in high-speed electrolytic tinning lines. Through extensive product improvement programs, the first cost of such equipment has been greatly reduced in the last ten to 15 years. In the early and middle 1940's the cost of such equipment was about $400 per kw; today it is about $300 per kw. These reductions resulted in improvement of individual circuit components and overall simplification of circuits and physical arrangements. Normally, the cost of a radio-frequency generator, increases as its frequency decreases for a fixed power output rating. In view of this fact, the reduction in price is even more spectacular because the operating frequency employed for tin lines has been reduced from about 200 kc to less than 100 kc. Installed in the steel industry today are some 17,000 kw of this type equipment.

Figure 9 shows a view of metal-enclosed, magnetic amplifier voltage regulators for a four-stand tandem cold reduction mill. There is a minimum of required interconnections between equipment. This reduces installation costs.

The author points out in the opening of his paper the importance of comparing the projected costs against the projected benefits for proposed installations. Today the steel industry is looking for better controls to measure this objective. Such equipment is being made available. It is expensive but produces beneficial results. Such new products as automatic gage controls, static switches, and computer type programming controls have been developed and are being used by the industry, to advantage.

Figure 10 shows a view of a card-programmed, digital controller used to automatically control the operation of a reversing roughing mill. The fact that costs of reliable transistors have fallen in the last few years through continuous development work has reduced the cost of this equipment. The fact that much progress has been made in the design of computing circuitry did no less.

E. B. Fitzgerald: Most companies today ask not only "How much does it cost?" but "What is the return to the company on this investment?" Companies that have set up a program of equipment replacement go all out to get equipment into the plant that shows a return on investment at or above the minimum requirements.

Companies use various methods of establishing the line that determines whether they will replace equipment or not. The MAPI formula, pay-off period formulas, and return on investment formulas are all methods of establishing this line.

As long as the proper return on the investment is maintained, management will have a favorable attitude to replacing old equipment. A program that was properly set up will have gone through all the steps of finding the equipment that will yield the highest rate of return to the company. Many times this is not the equipment of least cost. A company may well spend more for equipment that has less maintenance, less downtime, or that will just last longer.

Wherever possible, companies should certainly continue to look for cost reduction of which lower total installed costs are factors. In order to gain a larger share of the market, capitol goods manufacturers are continuously working to get the total cost of installed equipment lower. It should always be kept in mind, however, that the total installed cost is only one factor of many considered in determining which equipment a company should buy.

G. M. Baughman: Mr. Vonada mentioned that equipment costs 20 to 25 years ago were about one-

third of today's costs. This is a conservative statement. These price increases are not only due to higher labor and material costs but also the trend towards higher speed and more elaborate and complex equipment. Fortunately, many of the improvements in design of processing line equipment have resulted in such tremendous production increases that the over-all results show that the capital equipment cost per ton of steel processed has changed very little.

The continuous strip pickling process is an example. In the early 1930's the cost of a line completely installed would be about one-tenth the cost of a modern high-speed line. However, the production capacity of the modern line is more than ten times the capacity of these older models. One of the principal problems encountered with the first pickle line installations was making them operate at slow enough speeds to pickle the steel product efficiently. It was actually necessary in those early days to pickle at speeds below 40 fpm—today we are operating lines at speeds over 600 fpm. This movement towards higher speed, more complex strip handling equipment has greatly affected the type of electrical equipment required and the quality of the installations. There is no doubt that the high standards established, particularly by the larger steel plants, have contributed to improved performance, reduced maintenance costs and improved efficiency, but they have also resulted in higher capital investment costs.

In recent years electrical installation costs have become a higher percentage of the over-all erection costs of these lines because of the more complicated nature of the electrical control and the demand of higher standards. In the past, foundation work, machinery erection, and piping represented the major percentage of installation costs. In recent years we have found that electrical installation costs for high-speed processing lines are often a higher expenditure than all the other erection costs combined.

We have found that use of packaged drives, where applicable, substantially reduces installation costs. For example, the use of packaged drives instead of the generally accepted standard calling for separate motor and control room construction, resulted in a $30,000 reduction for electrical equipment, that had been originally priced at $200,000. Such a saving is certainly worthwhile.

Because packaged drives have been successfully applied to small process lines, application of them to more complicated lines is being investigated. As a matter of fact, we are now furnishing packaged drives for all the process lines in a complete stainless steel finishing facility of a large steel plant. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer*, a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those thought to be of primary interest to the American steel plant operator. The papers may be obtained from the Cooperative Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S. W. 1, England. All correspondence concerning price, ordering and so forth should be directed to the preceding source.

553 LIHL, F., and P. ZEMSCH: "The Effect of Annealing Conditions on the Core Loss of Hot-rolled Transformer Sheet," *Arch. Eisenhuttenwesen*, 1955, Sept., pp 535–540.

941 BARBAZANGES, C., and A. RICHARD: "Construction of Electric Arc Furnaces," *L'Acierie Electrique*, 1957 (Cahiers du Cessid), No. 1, Part 1, pp 1–40.

980 KOTTMEIER, F.: "The Application of Centrifugal Shot Descaling Plants in Bar Drawing Plants *Stahl u. Eisen*, 1958, March 20, pp 358–364.

991 SHAPOLALOV, M. A.: "The Introduction of Reducing Gases into the Hearth of a Blast Furnace," *Stal*, 1958, No. 5, pp 385–390.

1009 BRANDI, H. T.: "The Phoenix Lance (PL) Process," *Stahl u. Eisen*, 1958, June 26, pp 889–890.

884 MAKELT, H.: "Two-roll Straightening and Multi-roller Straightening Machines for Round Bars, Tubes and Sections," *Werkstattstechnik u. Maschinenbau*, 1956, vol. 46, pp 603–611.

891 R. HROCH and A. KOVAL: "Casting of Steel Rolls for Blooming Mills," *Stevarenstvi (Prague)*, 1957, vol. 5, June, pp 161–168.

965 BRANCONI, V. VON, and F. W. GRIESE: "Planning of the Handling of Bulk Materials in the Ironworks," *Stahl u. Eisen*, 1958, vol. 78, April 17, pp 465–475.

975 JAUMOTTE, A.: "Two Multiple Gas Turbine Assemblies for a Belgion Ironworks," *Stahl u. Eisen*, 1958, vol. 78, No. 10, May 15, pp 658–663.

688 KHOKHLOV, D. G., et al.: "Experiences with Automatic Speed Control of Sintering Machines for Ensuring the Completion of the Process," *Stal*, 1957, June, p 481.

689 FIL, N. S., and I. S. LEMBERIKMAN: "Conveyor Charging of Blast Furnace Skips," *Stal*, 1957, June, p 493.

735 GANICH, A. A., et al.: "Automatic Apportioning and Weighing of Blast-furnace Burdens and Conveyor Belt Loading of Skips," *Stal*, 1957, June, p 496.

769 NURNBERG, W.: "Results of Testing the Mode of Operation of Blooming Mills. III—Stressing and Mode of Operating of the Electric Drive," *Stahl u. Eisen*, 1957, October 31, pp 1593–1607.

976 FISCHER, W. A., and M. WAHLSTER: "Experimental Basic Converter with Continuous Bath Temperature Measurement and End Point Determination," *Stahl u. Eisen*, 1958, May 15, pp 646–654.

1015 SIEGFRIED, W.: "Control of Flow of Liquid Metals during Continuous Casting."

1017 KRAINER, H., and B. TARMAN: "New Experience in the Continuous Casting of Steel."

1018 THOMAS, P.: "The Continuous Casting of Steel in France in 1958."

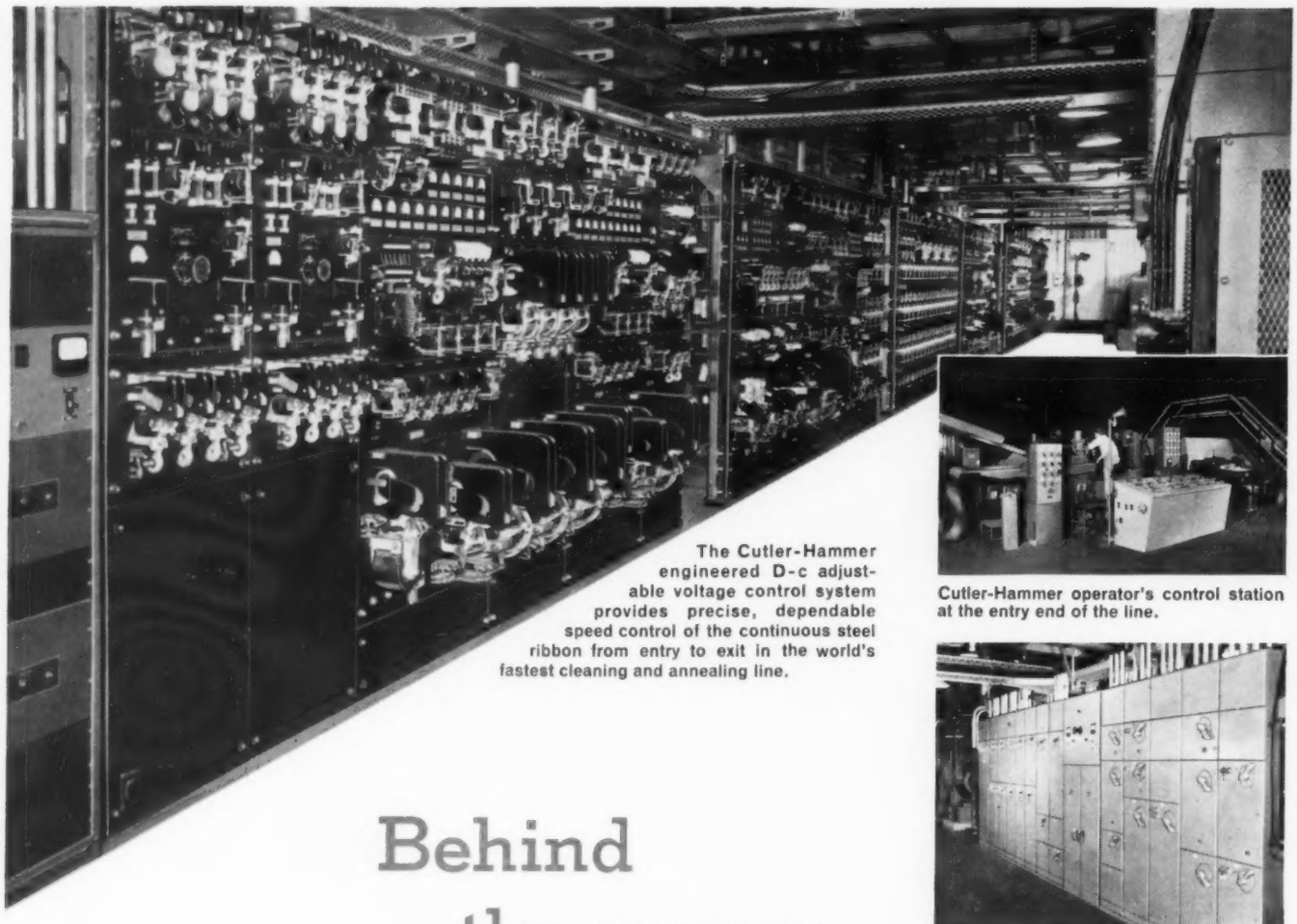
1023 FECHTER, F.: "Pusher-type Furnaces with Full Automatic Control and Ceramic Skid Rails," *Stahlu. Eisen*, 1958, March 6, pp 299–303.

1030 HANSEN, M.: "The Use of Models for Studying Flow in Open Hearth Furnace Checkers," *Stahl u. Eisen*, 1958, June 12, pp 804–812.

WEIRTON
STEEL COMPANY

WEIRTON STEEL COMPANY

NATIONAL STEEL



The Cutler-Hammer engineered D-c adjustable voltage control system provides precise, dependable speed control of the continuous steel ribbon from entry to exit in the world's fastest cleaning and annealing line.

Cutler-Hammer operator's control station at the entry end of the line.

Cutler-Hammer Unitrol provides a convenient, space-saving unit for all A-c auxiliary controls.

Cutler-Hammer 505 Mill Brakes are used on the winding reels and bridle stands.

Cutler-Hammer operator's control station at the exit end of the line.

Behind the scenes at Weirton Steel...

Cutler-Hammer Control keeps the world's fastest continuous cleaning and annealing line on the go

The new continuous strip steel cleaning and annealing line at the Weirton Steel Company division of National Steel Corporation is truly a remarkable engineering achievement. It automatically cleans and anneals an endless ribbon of cold rolled steel at speeds up to 2,000 feet per minute . . . a new world's record. But of equal importance is the fact it can deliver 20,000 tons of steel ready for tin plating every month.

Unquestionably, a processing line such as this represents a major capital investment which must pay for itself through high speed, dependable production day after day . . . month after month . . . year after year. And to a great extent its successful operation depends upon the trouble-free performance of the control equipment which integrates and regulates the complex system of individual machines that go to make up the line.

Here Cutler-Hammer's 65 years of control engineering experience provided the expert "know-how" in designing the *right* control system, the *dependable* control system for this performance champion.

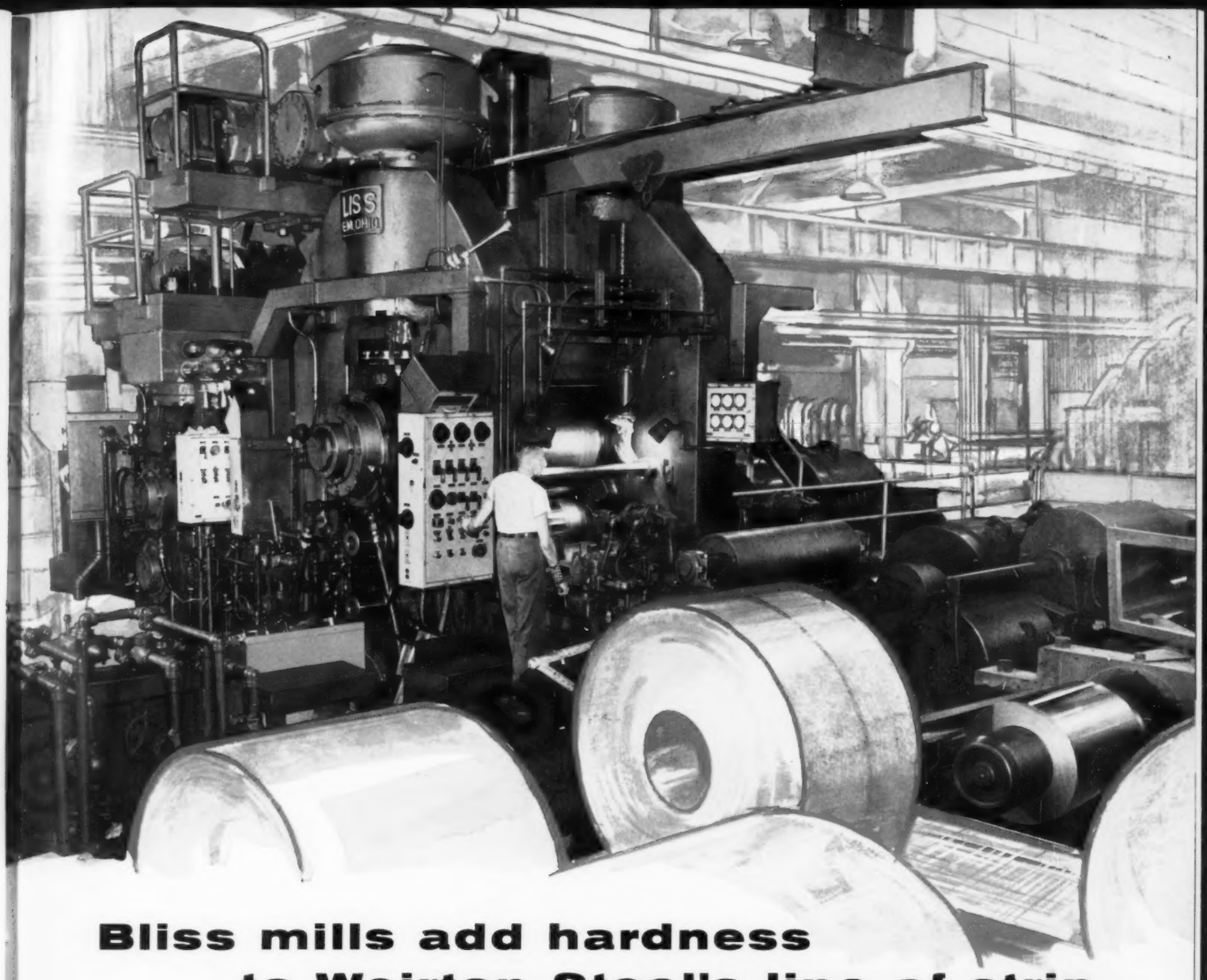
You too will find it pays to work with Cutler-Hammer for the practical solution to all your mill control problems. Your inquiry will receive prompt attention. Write Department W200, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
CONTROL
C-H

LOOK TO CUTLER-HAMMER MILL EXPERIENCE . . . AS BROAD AS IT IS LONG

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.



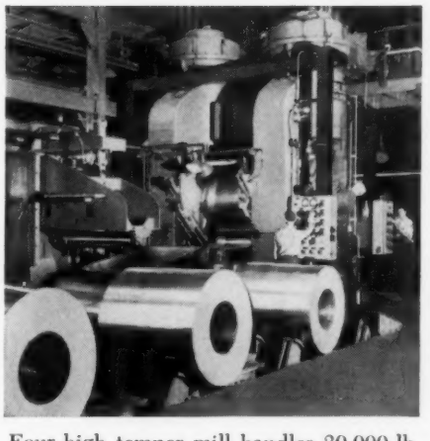
Bliss mills add hardness to Weirton Steel's line of strip

Weirton Steel Co., Division of National Steel Corp., the nation's largest independent producer of tin plate, uses a Bliss mill to achieve exacting temper and quality of its strip prior to plating. It is a four-high, two-high two stand tandem mill recently installed in its Weirton, W. Va., plant.

Through this unit Weirton has rolled a wide variety of steels in gages ranging from .00435 to .0147 inches and at an average maximum speed of 4,500 feet per minute. Well known products such as Weircote and Weirzin zinc coated steel are just two of Weirton's steel products to which this mill contributes.

A second Bliss mill tempers high-carbon, high-phosphorous, deep-drawing and galvanizing steels at the rate of 800 tons a day, while a new Bliss 48-inch slitting line is used to slit galvanized steel in gages from .0135 to .135 inches at speeds of 200 to 1,000 fpm. Both rolling mills are equipped with Amerigear-Bliss spindles.

These three installations provide one more example of the ready acceptance of the name of Bliss in the rolling mill industry—both here and abroad. To learn how Bliss equipment can help increase your rolling capacity, simply write for our new 84-page Rolling Mill Brochure, Catalog 40-B.



Four-high temper mill handles 30,000-lb. coils at speeds up to 3,500 fpm...has rolled 1,000 tons in a single day. Back-up rolls were supplied by Bliss' Mackintosh-Hemphill Division.

BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E.W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

Blaw-Knox Equipment at work on World's Largest Open Hearth

Meeting the operating requirements set for the new 600-ton open hearth at National Steel's Weirton Division took some of the biggest water-cooled equipment ever made. Loftus Engineering Corporation, builder of the furnace, and Weirton Steel chose Blaw-Knox Equipment to do the job. Water-cooled doors and frames, reversing valves and dampers as well as the latest mechanical accessories were specially designed and fabricated by Blaw-Knox to meet tough demands for record output. In measuring up for the job, Blaw-Knox called on more than fifty years of skill and experience in designing and building open hearth accessories.

Keeping pace with new and more efficient steelmaking techniques is a habit with Blaw-Knox. Our engineers are always available to discuss the latest developments in equipment and its application to your operation.

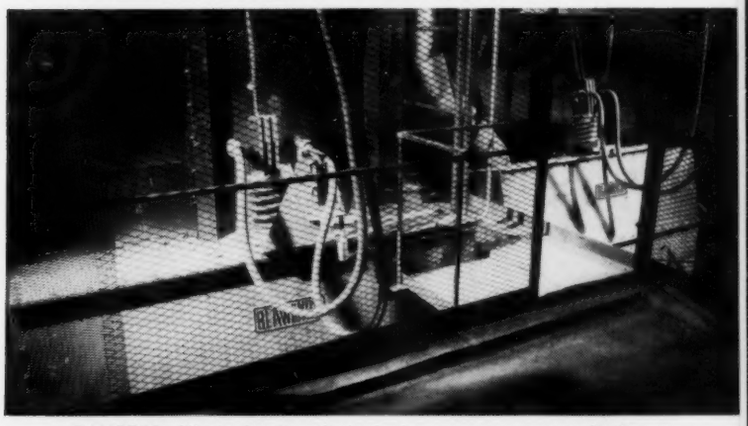
BLAW-KNOX

BLAW-KNOX COMPANY

Blaw-Knox Equipment Division

Pittsburgh 38, Pennsylvania

SLAG CARS—Two specially-designed slag cars handle front flushing of the furnace. These counter-weighted cars carry 11-foot diameter slag pots. Each car weighs 19 tons, is remotely controlled. When full, each slag pot weighs more than 61 tons.



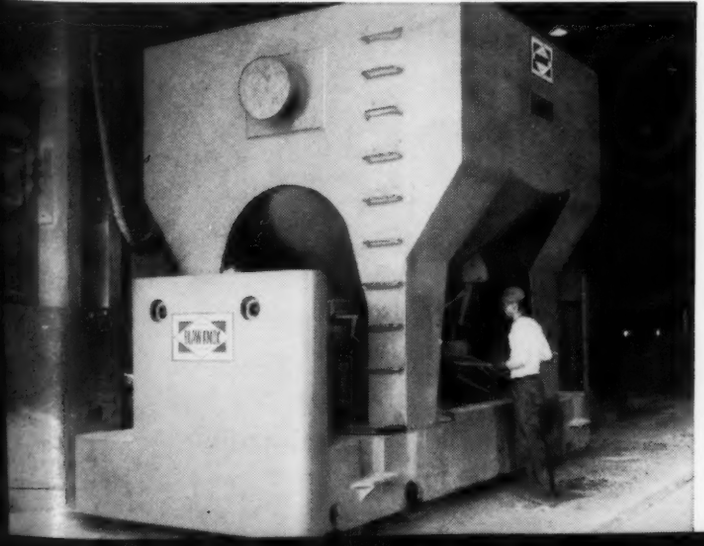
DAMPERS—Waste heat and stack dampers are unusually large; have 8′ x 8′ openings. The furnace is the fourteenth to be installed in Weirton's open hearth shop which is considered to be the highest producer in the world.

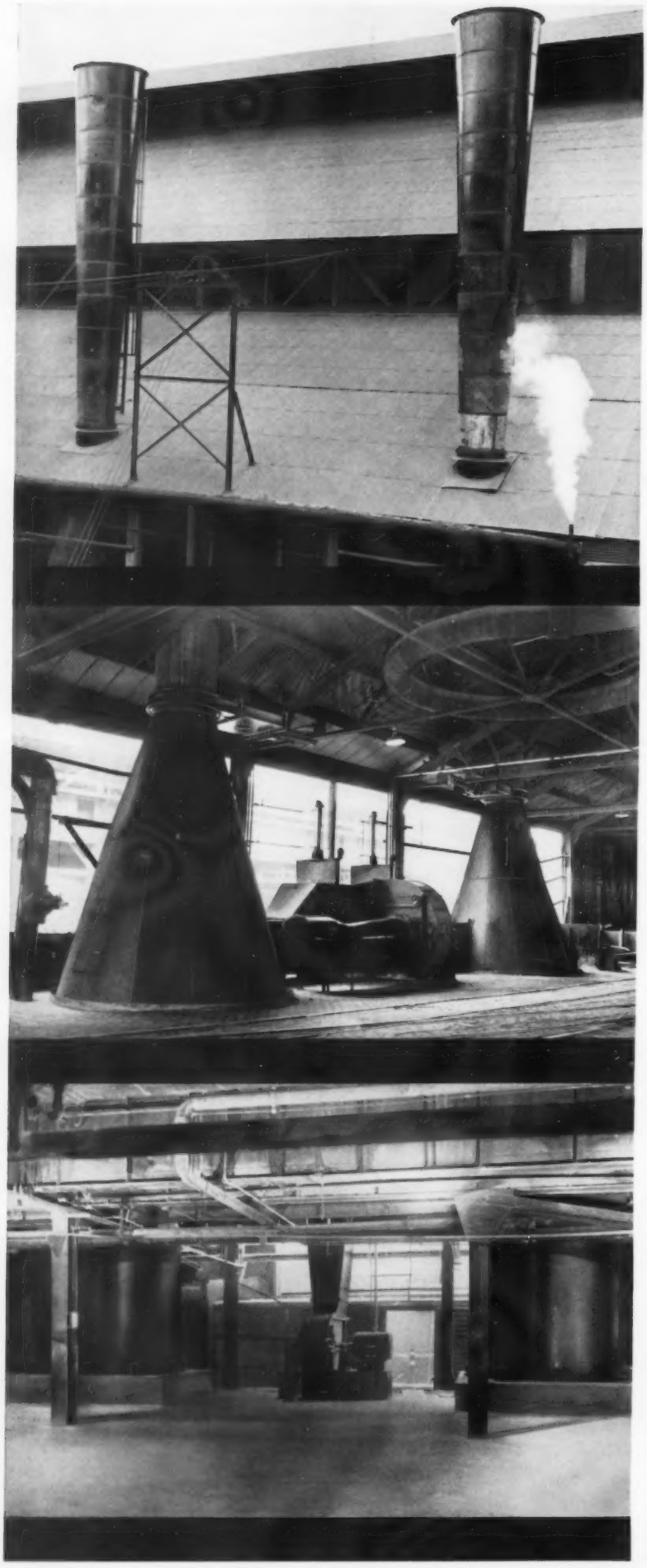
LADLE ADDITION FEEDER—Two vibratory ladle additions feeders eliminate manual handling of ferro-manganese. The amount and distribution of manganese is fed at an even rate which can be controlled to suit individual heat specifications.

DOLOMITE MACHINE—Equipped with a 500 cubic-foot hopper, this latest model can be operated from either end and the operator's side. A Diesel engine drives the main hydraulic pump which in turn drives car wheels and throwing mechanism.

REVERSING VALVES—Double deck reversing valves on the Weirton Furnace are among the largest operating in the industry today. Lower opening is 8′ x 8′; upper opening 3′ x 8′.

DOORS AND FRAMES—Seven water-cooled doors, each six feet wide by more than five feet high above the sill line, are spaced to permit simultaneous front flushing. The furnace is 111 feet long and 30 feet wide. Bath depth is 46 inches.





Plus Efficiency

FROM BASE TO STACK

MORGAN-ISLEY

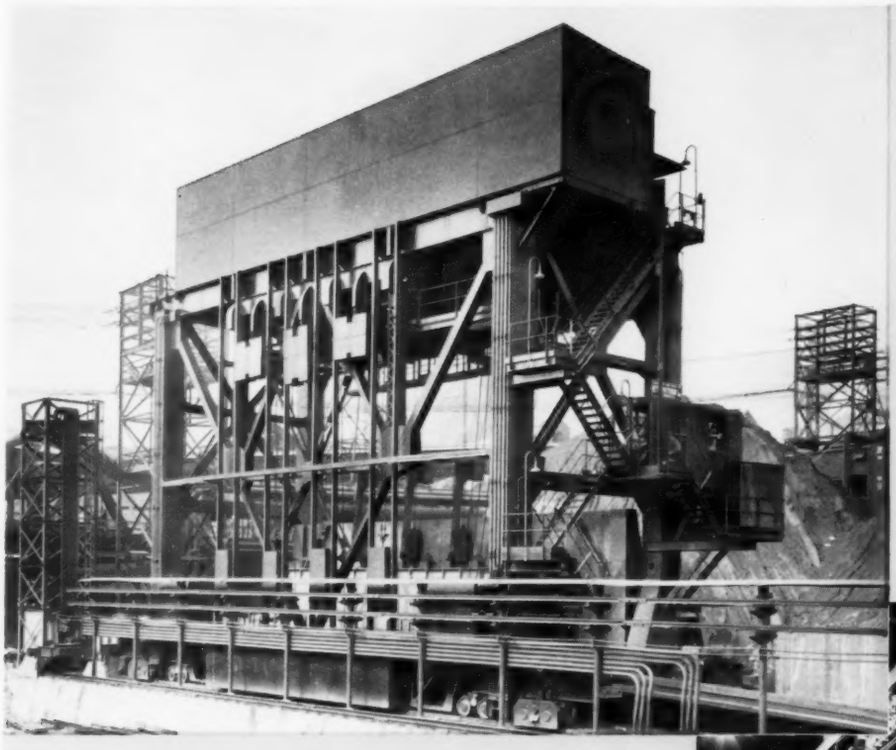
COMBUSTION CONTROLS

The installation pictured to the left is in operation at the National Steel Corp., Weirton Steel Company Division plant in Weirton, West Virginia. The Morgan-Isley Combustion Control System affords the Weirton Steel Company a method of efficiently supplying combustion air and exhausting combustion waste products. The system provides additional checker capacity which returns more heat. It increases production because it produces faster heating.

MORGAN
WORCESTER

ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - EJECTORS
REGENERATIVE FURNACE CONTROL

CCCSS



Heyl & Patterson
Car Dumper

P-G Resistors
control this 300 ton car dumper

Non-breakable Post-Glover resistors do their part in keeping this 300 ton car dumper in round-the-clock operation at Weirton Steel Company division of National Steel Corporation, Weirton, West Virginia.

These rugged, shock resistant P-G Standard Unit Resistors are built of steel and mica. With nothing to break, they have afforded low cost protection to many types of expensive and vital electrical equipment for more than twenty years.

When you want "continuous trouble-free service" specify, P-G the ORIGINAL Steel Grid Resistor.

Note that ample terminals are available for adjustments if required to meet actual operating conditions.

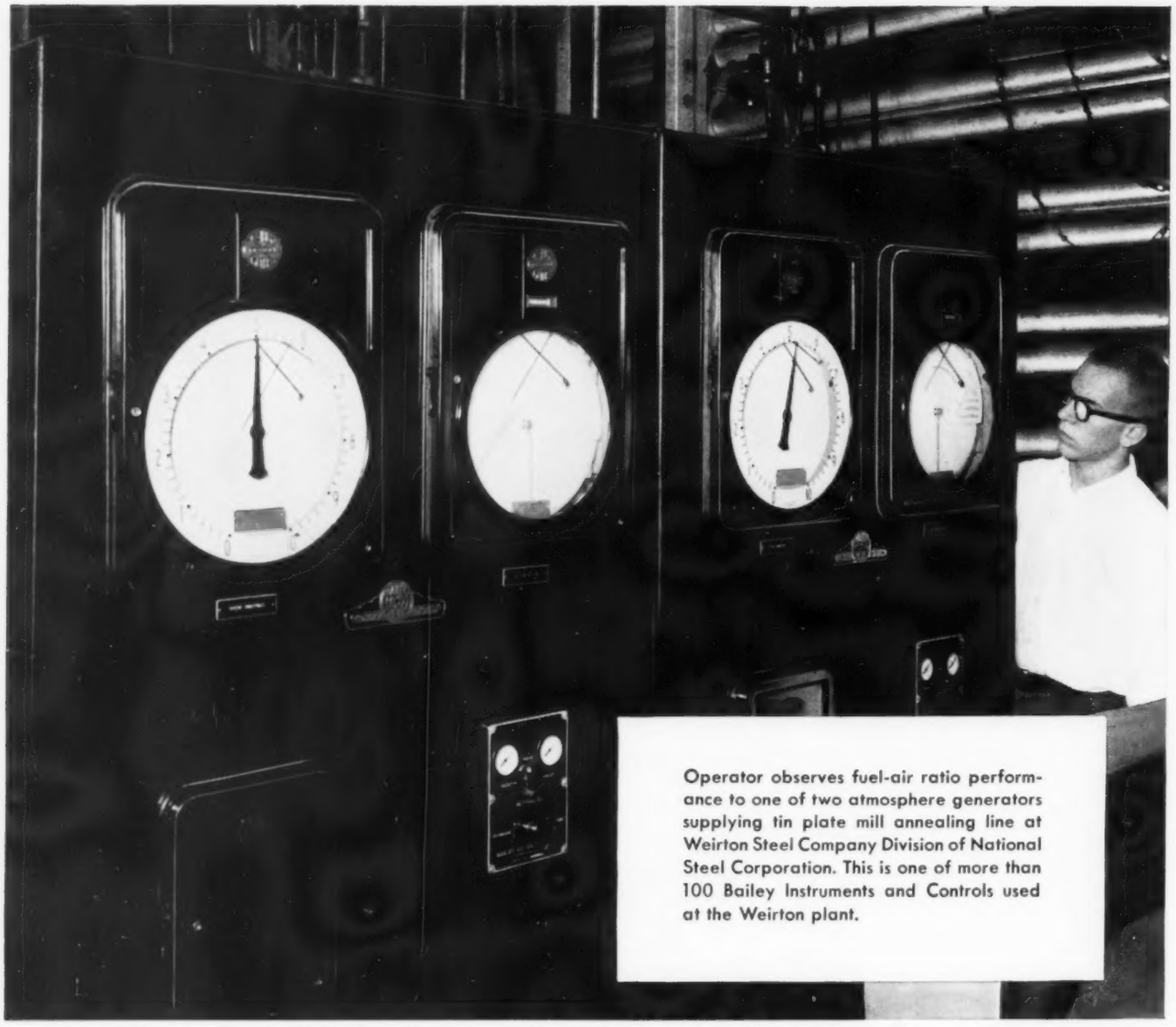
Established 1892

Write for Bulletin No. 500

THE **POST-GLOVER** ELECTRIC COMPANY

OFFICE and FACTORY—Kenton Lands Road, Erlanger, Kentucky

MAILING ADDRESS—Box 709, Covington, Kentucky



Operator observes fuel-air ratio performance to one of two atmosphere generators supplying tin plate mill annealing line at Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls used at the Weirton plant.

Bailey Atmosphere Generator Control automatically regulates total combustibles for tin plate annealing

Bailey's Atmosphere Generator Control is a completely packaged automatic control system which measures *total combustibles* in annealing.

Manual settings are made only during start-up or shutdown. Fuel-air ratio to generators is adjusted by the control system to maintain constant total combustibles despite variation in fuel quality. Response to atmosphere changes is fast, and total combustibles are accurately measured, since the Bailey Analyzer is not subject to errors due to variability of other atmosphere constituents. The Analyzer is sensitive to changes of less than ±0.02% total combustibles.

The performance of this instrument is assurance of final product quality. See your Bailey Engineer, or write the Iron and Steel Division for more information.

S112-1

IRON AND STEEL DIVISION

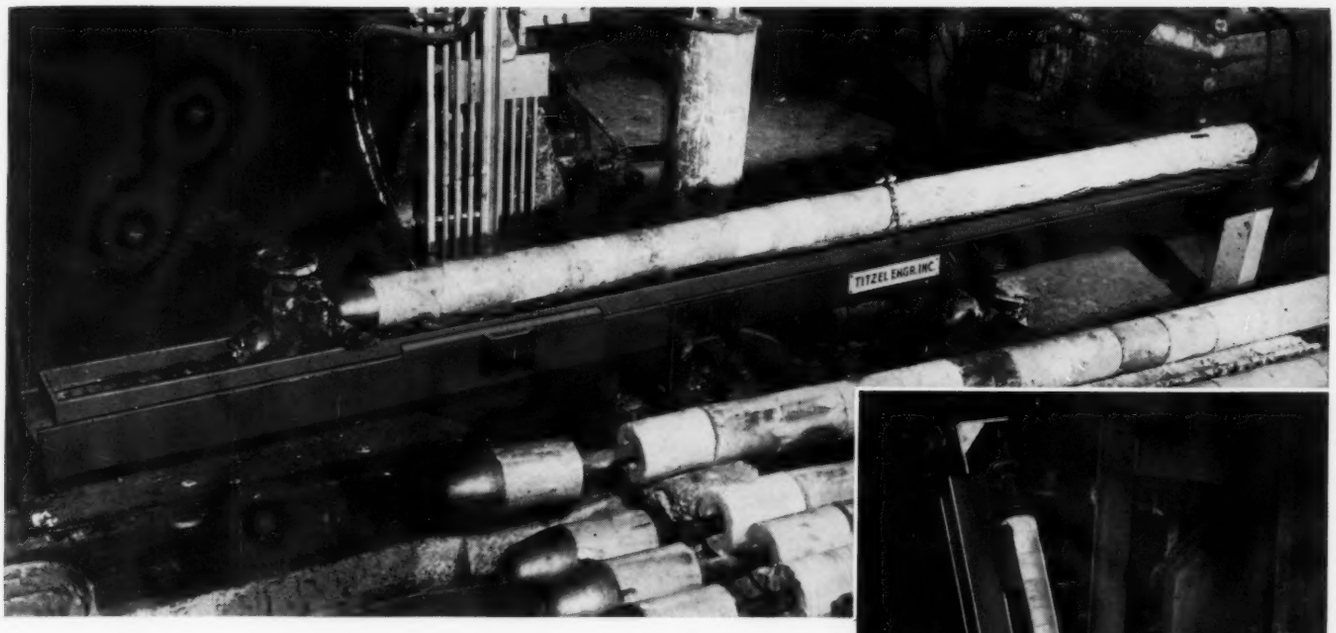
BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

Titzel Stopper Rod Drying Oven (Conveyor Type) at Weirton Steel Company



Like all Titzel Steel Mill Equipment, the Titzel conveyor type of Stopper Rod Drying Oven at Weirton Steel Company, a division of National Steel Corporation, was designed and built to give dependable service.

Shown above is the Titzel Mechanical Stopper Rod Tilting and Loading Unit, and on the pouring side of the furnace at Weirton Steel you will find the Titzel Jib Crane for handling the hot metal pouring spout.

All the Way from Design to Installation

• JIB AND CASTING PIT CRANES FOR OPEN HEARTH DEPARTMENTS • HOT TOPPING AND CAPPING CRANES FOR INGOT MOLDS • JIB, PILLAR, WALL AND FLOOR TRAVELING CRANES • BUTTON AND SKULL BURNING CRANES FOR SCRAP YARDS • STOPPER ROD DRYING OVENS • HYDRAULIC Ddescaling SYSTEMS • MILL SCALE HANDLING SYSTEMS • PALM OIL SYSTEMS • PNEUMATIC, HYDRAULIC AND MECHANICAL CONVEYORS • MILL DUST HANDLING SYSTEMS

TITZEL *ENGINEERING, INC.*

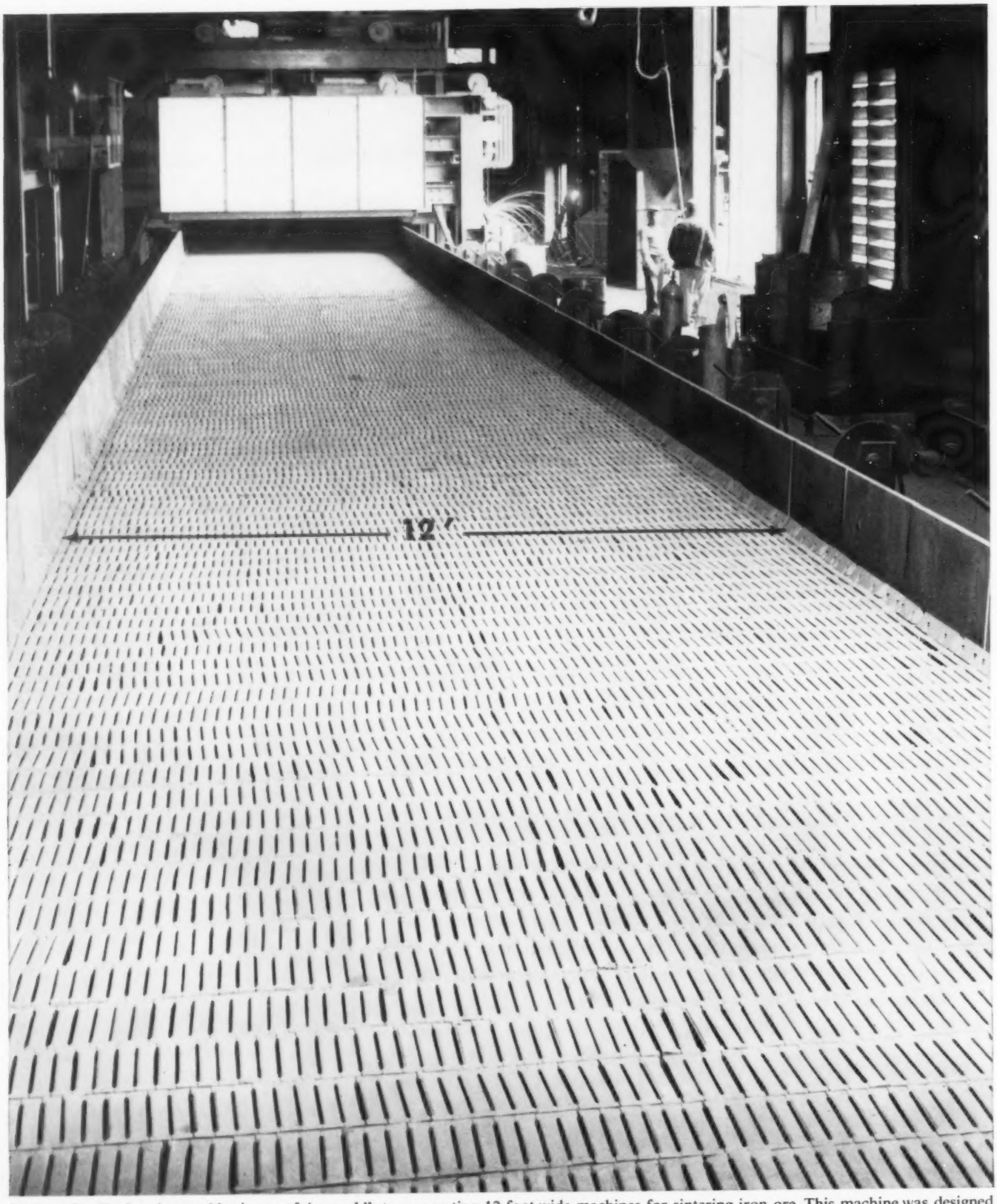
PITTSBURGH 22, PA.

• DESIGNERS & MANUFACTURERS OF SPECIAL EQUIPMENT

Allied Company, Titzel Engineering and Equipment Co.

FOR NATIONAL STEEL

KOPPERS BUILDS WORLD'S



Weirton Steel's sintering machine is one of the world's two operating 12-foot wide machines for sintering iron ore. This machine was designed to produce a minimum of 5,500 tons of sinter product per day.

LARGEST SINTERING MACHINES

The two largest iron ore sintering machines in the world—both 12 feet wide—are now in operation. Both are part of plants built by Koppers. Both are helping Divisions of National Steel Corporation improve productivity.

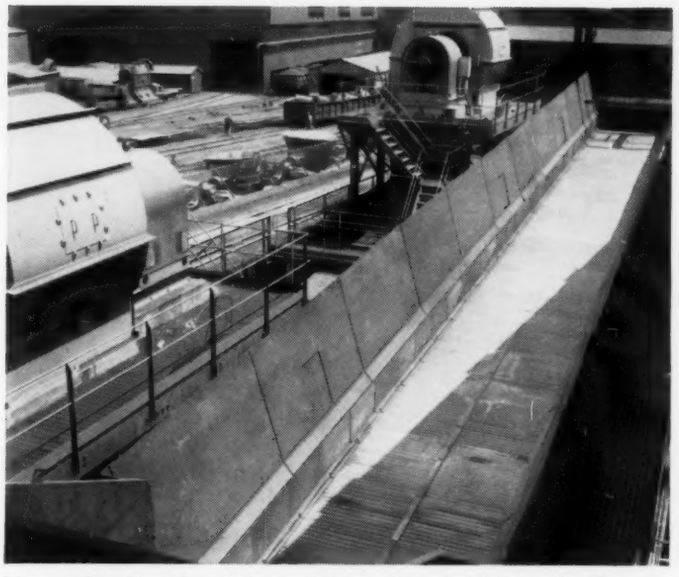
The machine shown here is operating at Weirton Steel Company. It is 12 feet wide, 147 feet long over the wind boxes, has a total grate area of 1,764 sq. ft. It was designed to produce 5,500 tons of sinter product per day.

An even larger machine is also in production at Great Lakes Steel, another Division of National Steel Corporation. This new giant is 12 feet wide and 199 feet 6 inches long over the wind boxes. It was designed to produce 7,200 tons of sinter product per day.

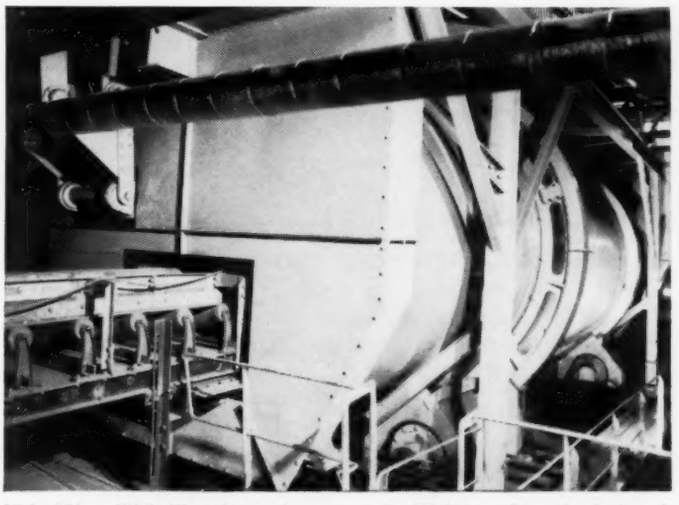
These two pioneering machines are typical of the continual modernization program being carried on throughout the National Steel organization. A forward-looking approach on the part of National Steel's operating and management personnel, and their complete co-operation and assistance during every phase of engineering and construction, contributed greatly to the successful completion of these two projects by Koppers.

Comprehensive Koppers service to the steel industry includes design, engineering, procurement, construction and initial operation of almost any type of equipment.

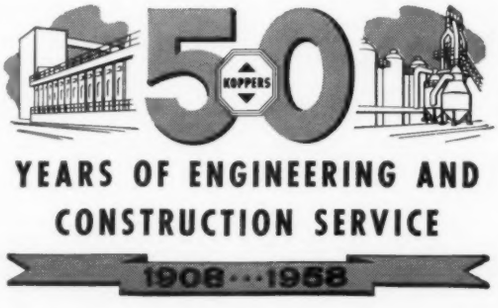
If you need help or advice on any expansion or modernization project, call on Koppers—the world's largest, most experienced, best qualified steel-plant construction firm. Our engineers and management personnel can be reached at Koppers Company, Inc., Engineering and Construction Division, Pittsburgh 19, Pennsylvania.



The straight-line, forced-draft sinter cooler of Weirton Steel's new sintering plant is 10 feet wide, 147 feet long.



This 12′ x 40′ balling drum, in use at the Weirton plant, is designed to prepare the raw mix material fed to the sinter machine.



KOPPERS

HE CAN "MEASURE" MORE PROFIT FOR YOU. This Dowell service engineer can measure the amount of scale he removes from a line, using the Dowell method of chemical cleaning. *This removed scale and sludge can also be measured in increased profit dollars for your company.*

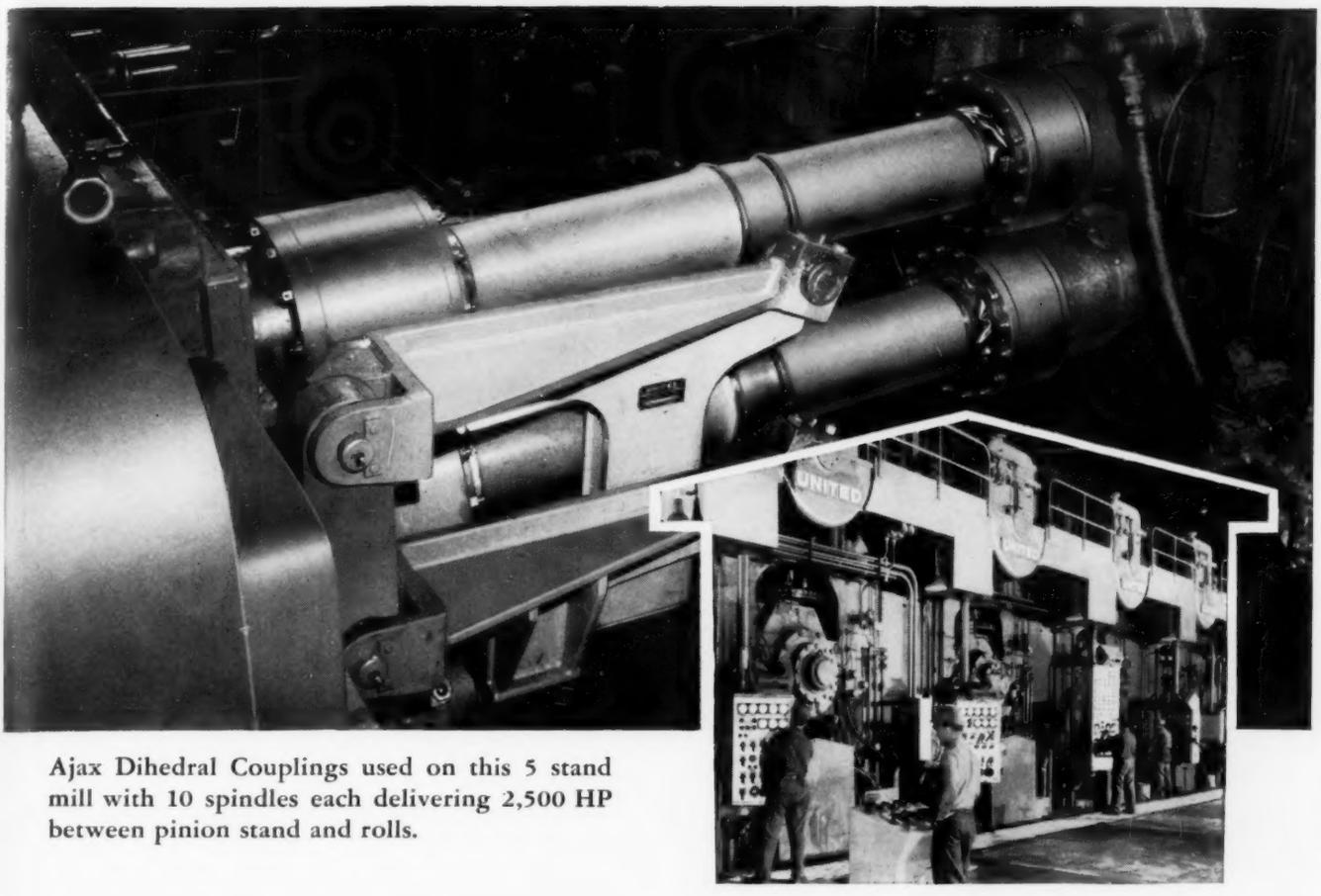
Example: Scale build-up in the main water supply line of a major Midwestern plant had reduced the "C" factor from 105 to 72. This situation became apparent just at the start of the peak season for the company. Management had a choice between laying an auxiliary line or trying to clean their present one. They decided to clean the line—but not the old-fashioned mechanical way. Time would not permit. Dowell was called in to do the job—chemically.

Dowell Service was fast—the job was done in three days. Dowell Service was effective—the "C" factor was increased to 92. Dowell Service was profitable for the customer—$71,000 was saved and the company's annual profit was protected.

With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus a full line of equipment, chemicals, and trained personnel. You pay one charge, get an efficient job, handled by experienced people.

Your maintenance and operating engineers probably know about Dowell Service. Ask them for the facts. Decide for yourself about the additional profit possibilities to your company with Dowell Service working for you. DOWELL—A SERVICE DIVISION OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma, with 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL



Ajax Dihedral Couplings used on this 5 stand mill with 10 spindles each delivering 2,500 HP between pinion stand and rolls.

AN OUTSTANDING PERFORMANCE RECORD ON AJAX ROLL SPINDLE DRIVES

AJAX Dihedral Spindle Couplings were selected for use on the new #7 Five Stand Tandem Cold Mill at Weirton Steel Company, Division of National Steel Corp.

Ten AJAX Dihedral Spindle Couplings have delivered the power to this mill for a continuous period of over two years without necessity of maintenance or replacement.

Dependable and maintenance-free performance, such as outlined above, will not only reduce your operating costs but will give you better product quality.

Experience proves that it will pay you to modernize your spindle drives now with AJAX Dihedrals and also specify them on new mills. We will welcome the opportunity of surveying your spindle coupling requirements. Many outstanding applications of AJAX Dihedral Couplings on difficult jobs provide our Sales Engineers with practical background to aid in solving your problems and improving your operating conditions.

Write or phone FAirview 6-3121 for latest AJAX Dihedral Bulletin 64.

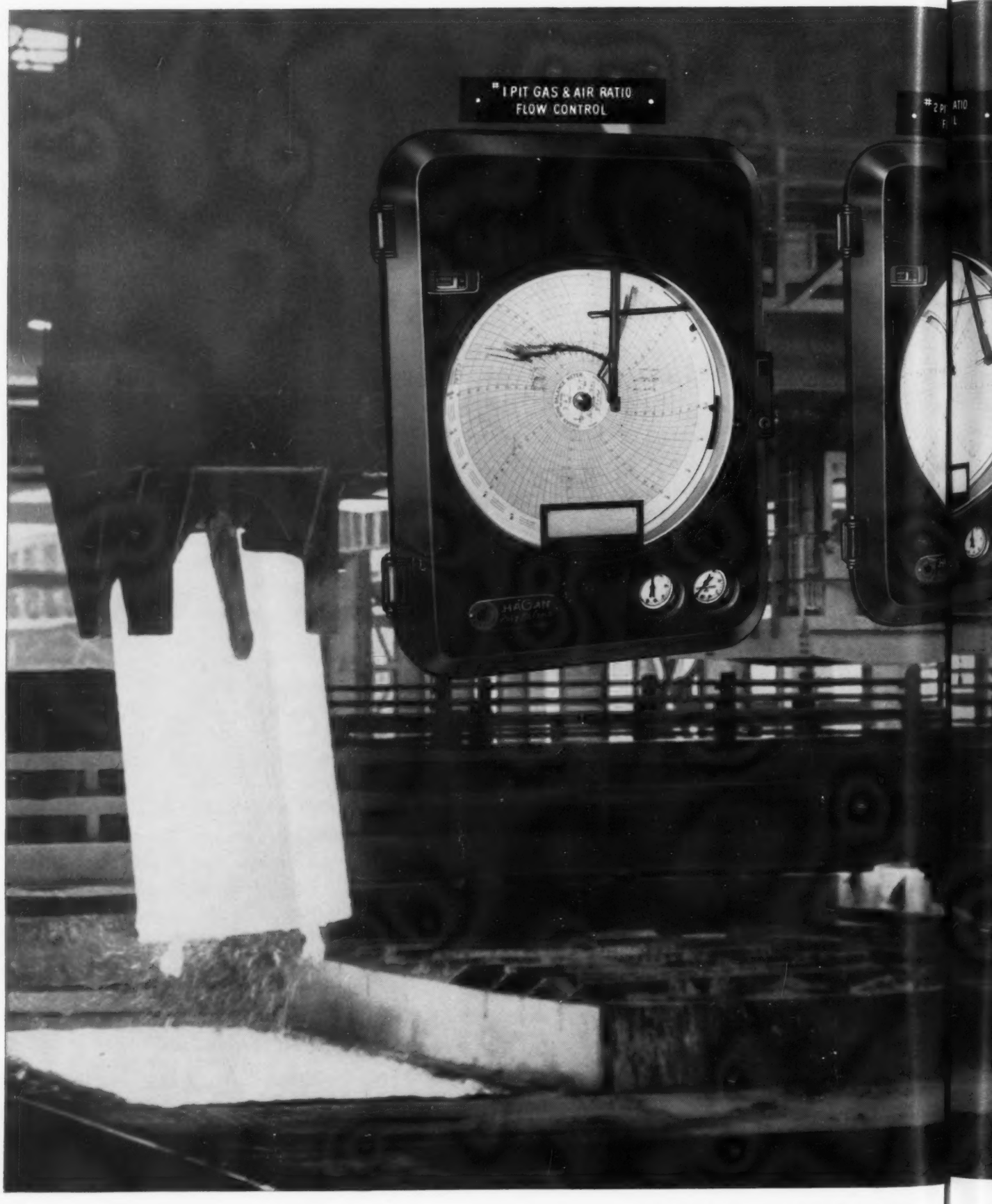
AJAX®

Inquire from the operating personnel at Weirton regarding their experience with AJAX Dihedral Spindle Drives.

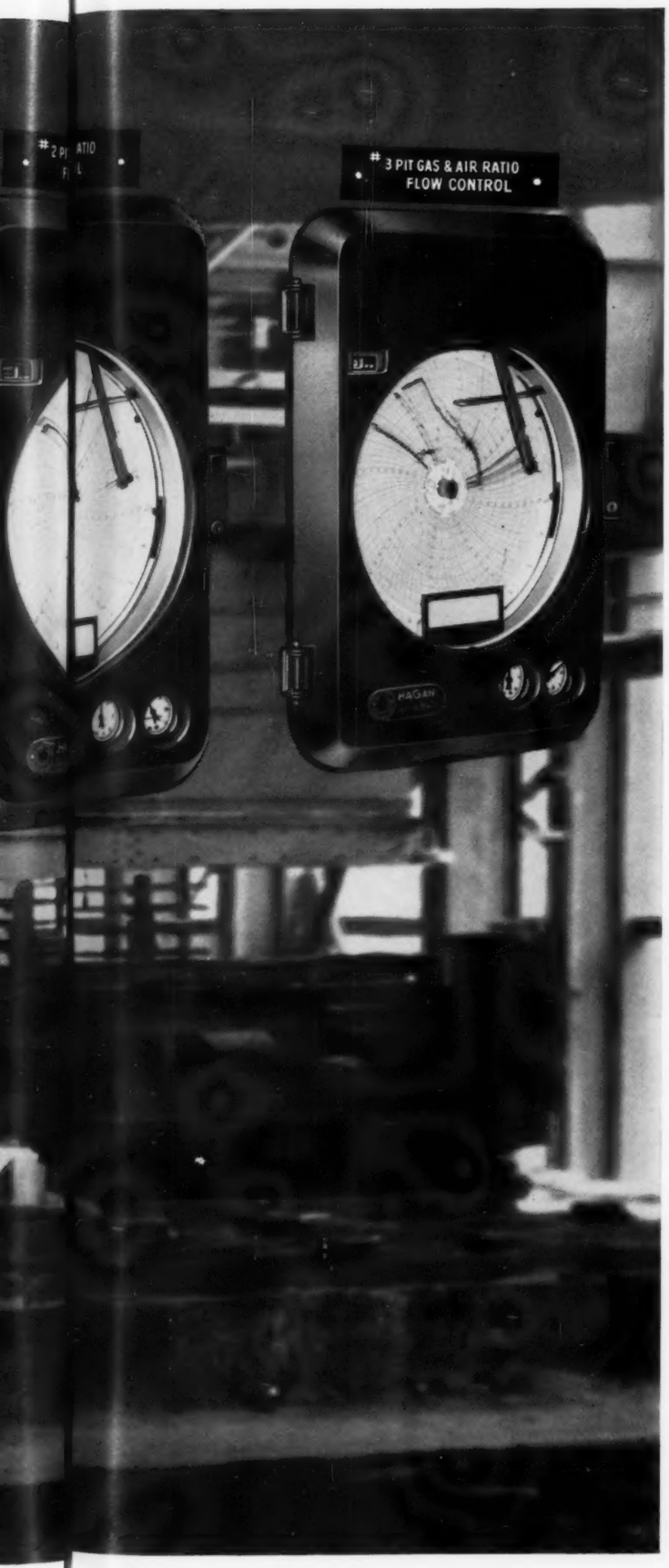
AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, N. Y. REPRESENTATIVES IN PRINCIPAL CITIES

Hagan Ring Balance



Meters do all three:



MEASURE, RECORD & CONTROL

on new soaking pits at Weirton Steel

Already established as the industry standard for soaking pit flow metering because of its fast response and accuracy at low flows, the Hagan Ring Balance meter now goes to work as a fuel-air ratio controller having the same desirable characteristics.

PRE-PACKAGED PERFORMANCE—One instrument case houses the air flow and gas flow measuring rings and recording pens plus the ratio controller with remote ratio adjustment and combustion air temperature compensator. A considerable saving in panel space was made possible and installation and start-up time was cut in half by the pre-packaged nature of the controller.

FAST RECOVERY—The control circuit operates air and gas valves simultaneously in parallel, with a correction from the Ring Balance fuel-air ratio controller applied to the position of the air valve. Fast recovery after cover operation is a feature of the fuel-air control as weli as of the flue pressure, gas pressure, and air pressure controls, all employing fast, rugged Hagan Ratio Totalizers and Power Positioners.

TROUBLE-FREE OPERATION—This control installation on two batteries of three holes each at the Weirton division of National Steel Corporation has been in service for a year, and operating personnel are well satisfied with its performance. They are especially pleased with the low maintenance requirements of the Hagan controls and the good housekeeping made possible by a pneumatic system.

Two more batteries of three holes each have been purchased and will be equipped with Hagan meters and controls.

Write for Bulletin MSP-141
for additional application information

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

Weirton Steel Repeats with the 4th H&P Ore Bridge

With these 4 Ore Bridges and the New H & P Traveling Turnover Car Dumper— Unloading, Stocking and Reclaiming of ORE at Weirton Steel is . . . . . .

Operating Since...

1926—**Bridge No. 1**

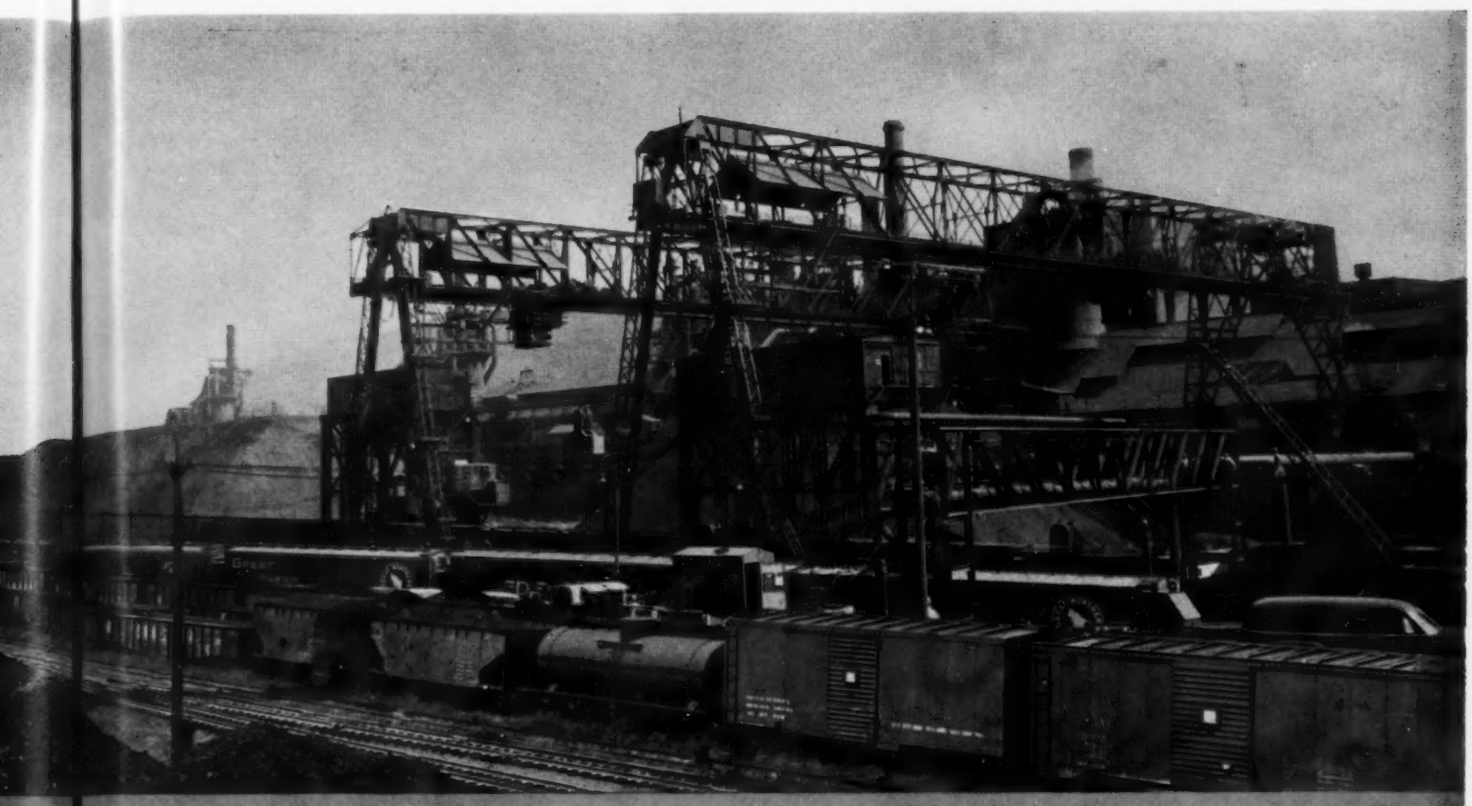
1942—**Bridge No. 2**

1952—**Bridge No. 3**

1957—**Bridge No. 4**

1958—**Turnover Car Dumper**

H & P Traveling Car Dumper handles RR cars with loads up to 110 tons.



HEYL & PATTERSON all the way!

Repeat orders such as these from Weirton Steel Company, Division of National Steel Corporation, provide proof of complete customer satisfaction. Some of the reasons for this preference are long life expectancy and dependability in operation. For instance, the original Bridge Moving Trucks on Weirton Bridge No. 1 are still in use.

Heyl & Patterson looks forward to the years ahead, confident of further opportunities to design, build and erect bulk material handling equipment for the **Divisions of National Steel Corporation and the Steel Industry.**

H & P Serves the Steel Industry with these time-tested products:

- ORE & COAL BRIDGES
- BOAT & BARGE LOADERS & UNLOADERS
- COAL & COKE HANDLING EQUIPMENT
- RAILROAD CAR DUMPERS ROTARY, TURNOVER
- ORE STOCKING CONVEYORS & TRIPPERS
- HYDRAULIC RAIL CLAMPS & BUFFERS
- PIG CASTING MACHINES
- SPECIALIZED CONVEYING SYSTEMS
- CAR HAULS & BOAT MOVERS
- BRADFORD BREAKERS
- THERMAL DRYERS
- WET CYCLONES
- KINNEY CAR UNLOADERS FOR STICKY OR FROZEN BULK MATERIAL

When Experience Counts–
Count on Heyl & Patterson
Since 1887

Heyl & Patterson INC.
55 FORT PITT BLVD., PITTSBURGH 22, PA., COurt 1-0750

"Home Comfort" Operation Improves Output at Weirton Hot Strip Mill

The production line you see above is a "Down Coiler" operation at the Weirton Steel Division Plant of National Steel Corporation. Steps in production are controlled by men comfortably housed in the James Campbell Smith Pulpit pictured to the far right. Here they are safer, work in air conditioned comfort. Result is high morale, increased efficiency, better production!

You, too, can enjoy the same profit-building benefits in your plant with a James Campbell Smith *Customized* Pulpit designed specifically for your needs. They can be insulated against heat, have special sound deadening walls and ceilings, be equipped with restful indirect lighting, air conditioning, drinking fountains, lavatories . . . any one of a number of special features you may desire. And—always—quality and workmanship are of the highest possible standard.

Write today for our free brochure. Learn how modern James Campbell Smith, Inc., Pulpits and Control Houses can help you improve your operation.

JCS

Originators and Developers of the Modern Mill Pulpit

James Campbell Smith, Inc.

4057 Erie Street, Willoughby, Ohio

The men with the peanuts

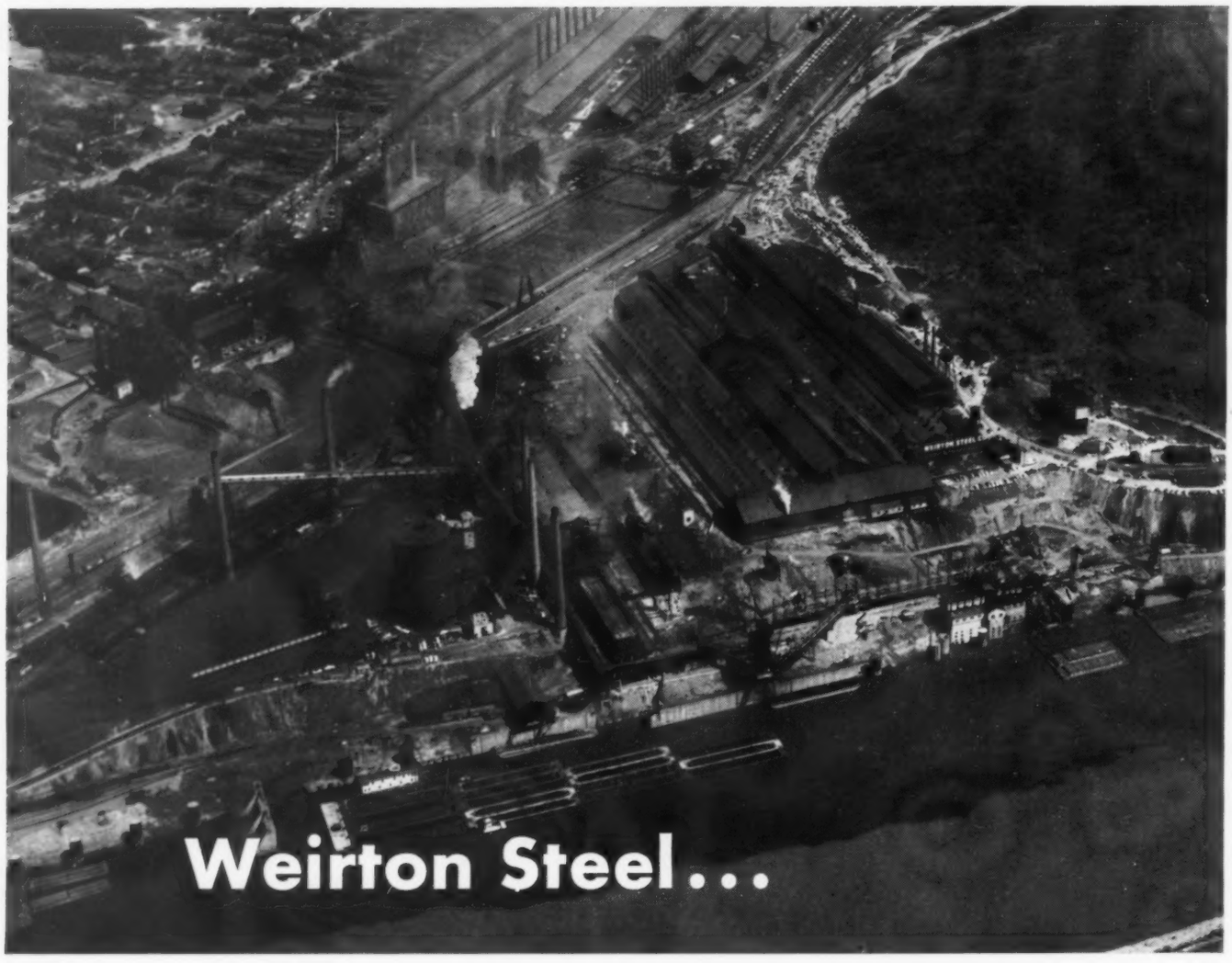
Aside from the fact that they are gang-poured, "peanut" rolls get the same careful treatment here at Mack-Hemp that is accorded the largest plate mill rolls. Mold preparation . . . alloying . . . melting and pouring . . . machining and grinding . . . each receives the same attention whether the roll weighs 140 pounds or 140,000.

This painstaking care at every step in production—an outgrowth of our 135 years' experience—is a principal reason why *you get more tonnage from the rolls with the striped red wabblers.*

MACKINTOSH-HEMPHILL
Division of E. W. BLISS Company
Pittsburgh and Midland, Pa.

MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH · U.S.A.

BLISS



12 year continuity in oxygen production with "on-location" generators

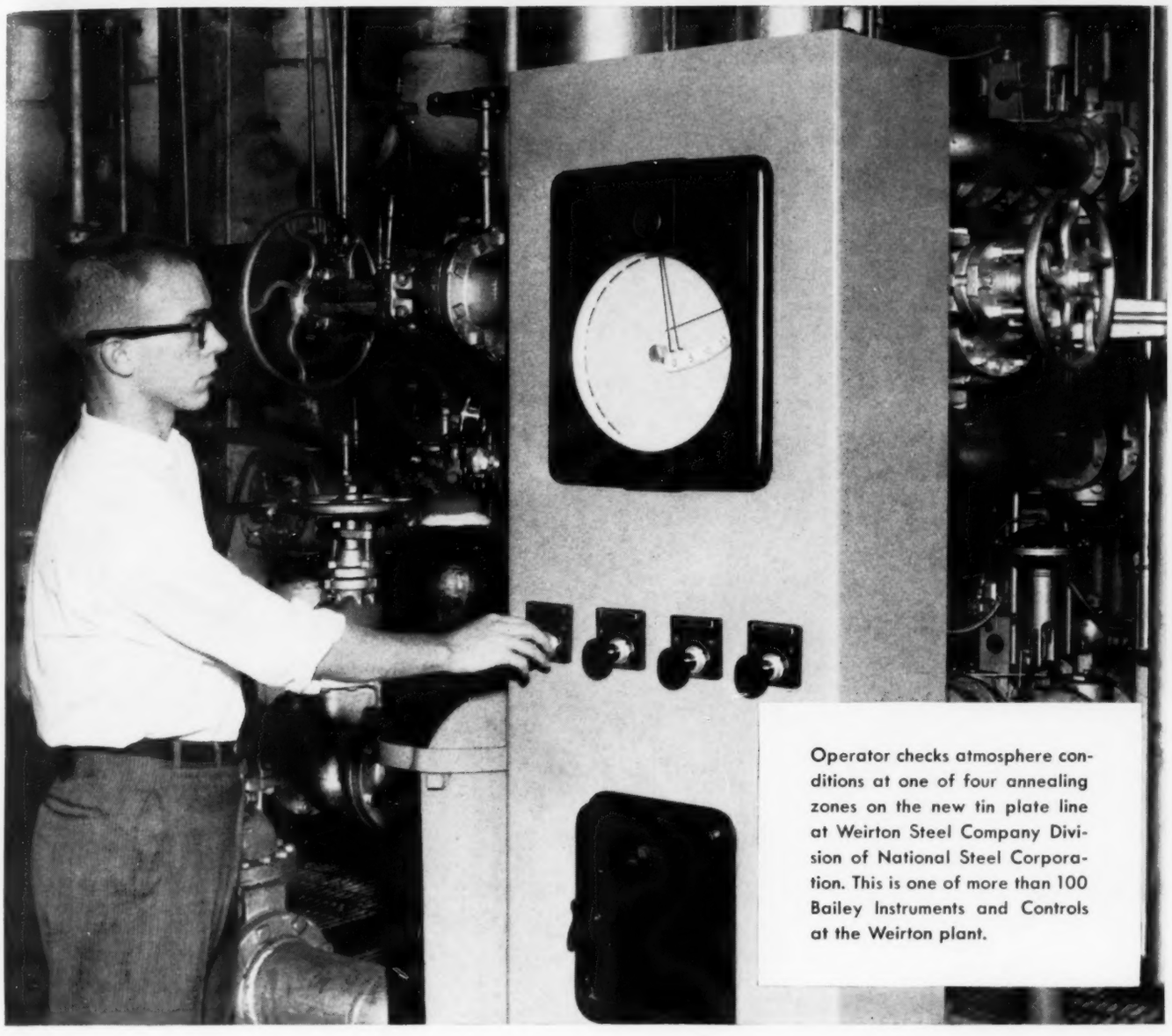
Since 1946, Weirton Steel Company, a division of National Steel Corporation, has obtained its oxygen requirements from "on-location" generators . . . designed and built by Air Products, Incorporated. Present production capacity is over 400 million cubic feet/month of oxygen . . . for all uses from blast furnace air enrichment to scarfing.

This continuity of a low-cost supply of oxygen over the years has been possible only through the use of dependable "on-location" generators—designed and manufactured by Air Products.

Continuity of supply at Weirton is a typical benefit resulting from steel companies' use of "on-site" oxygen generators. Other steel companies enjoy such profitable advantages as: substantial reductions in oxygen cost . . . dependable production of high purity oxygen 24 hours/day . . . flexibility in meeting increased or decreased demand through proper equipment sizing. Even plants requiring limited quantities of oxygen can profitably use Air Products generators.

Let us show you how you can have a dependable low cost supply of oxygen without capital investment. Air Products "on-site" oxygen generators supply many of the nation's leading steel plants. Your inquiry is invited. Air Products, Incorporated, P.O. Box 538, Allentown, Pa.

Air Products
...INCORPORATED



Operator checks atmosphere conditions at one of four annealing zones on the new tin plate line at Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls at the Weirton plant.

This Bailey instrument gives you 2 atmosphere checks for the price of 1

You can measure combustibles *and* oxygen with this Bailey Analyzer-Recorder . . . at less than the price of other instruments that make only single measurements.

Only Bailey gives you a continuous recording of *both* oxygen and combustibles on the same chart for quick, simple comparison. You can reduce costly furnace purging time by accurately measuring oxygen instead of guessing. Measuring oxygen also drastically reduces danger of explosion. The Oxygen Analyzer-Recorder can detect small furnace leakage of steel-scaling oxygen—thus assuring higher product quality.

The Bailey instrument is by far the most efficient and economical way of controlling atmospheric conditions in annealing furnaces. See your Bailey Engineer or write to the Iron and Steel Division for complete information.

5113-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

Top honors at

Since 1928 "Tool Steel Process" hardened products have been used at The Weirton Steel Company, Division of National Steel Corporation. Their phenomenally long wearing qualities are delivering great savings in maintenance, replacement and downtime costs.

Illustrated are a few of the many applications of TSP hardened products now in constant use throughout National Steel Corporation's many plants. They include cold rolling rolls, leveller rolls, cold processing rolls, all types of gears and pinions, drum sleeves, track wheels, sheave wheels, screwdown screws and nuts, shafts, axles, and other miscellaneous hardened products.

TSP hardened products outlast ordinary products many times over because they are made better. Only the finest material is used, specially hardened to deliver phenomenally long wear. All TSP products have a file hard surface to the full depth of permissible wear for maximum life. The core, refined for toughness and ductility, gives maximum strength. Every TSP hardened product is positively guaranteed in writing to outlast, outperform any competitive product in the same service. For more information on TSP products and applications, write today for complete descriptive literature.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U. S. A.

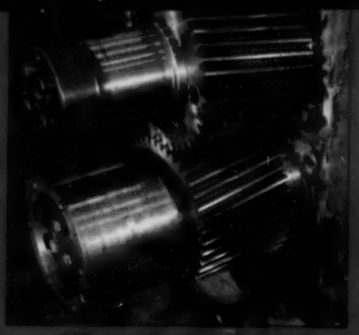
MEMBER OF AGMA

AD 1035—Printed in U.S.A.

The Standard of Quality Since 1909 for Gears, Pinions, Rolls, Wheels and Other Hardened Products

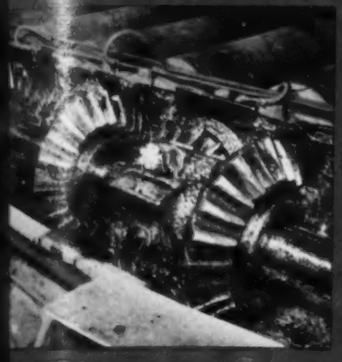
TSP track wheels on slab yard crane.

TSP pinch rolls on tin mill cleaning line.

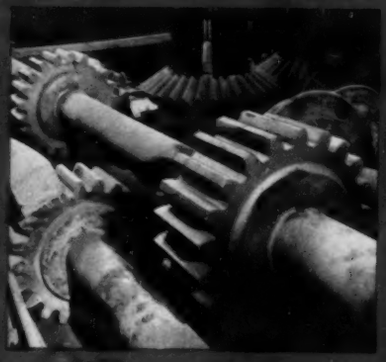


TSP Hallden shear gears.

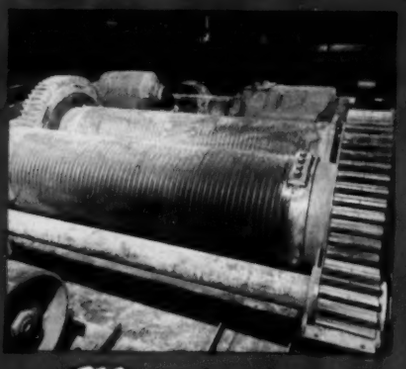
TSP sheave wheels on 175 ton ladle pouring crane.



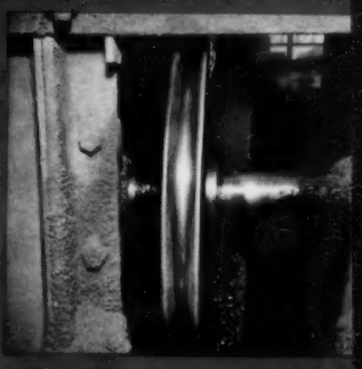
TSP bevel gears average 3 times life of competitive gears.



TSP manipulator rack pinion gears.

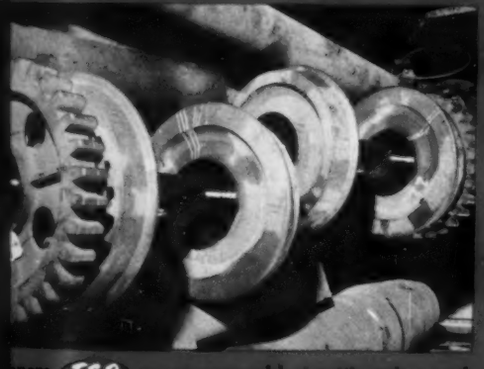


TSP rope drum sleeves.

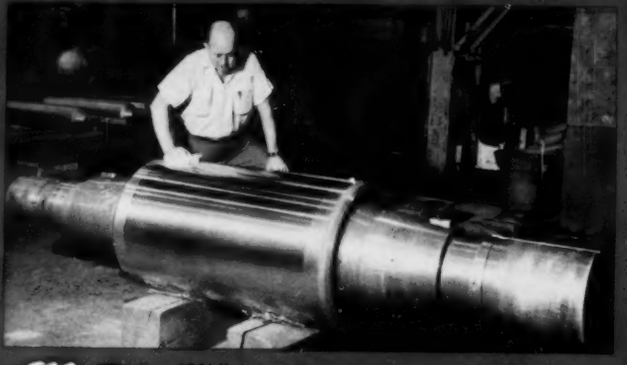


TSP sheave on coke hoist shows no wear after 28 months service. Competitive sheaves lasted 8 months.

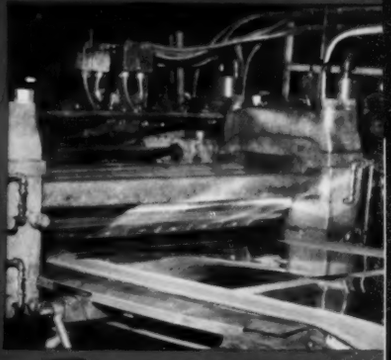
t WEIRTON STEEL



spare TSP gears assembled with axles and track wheels for No. 1 bridge.

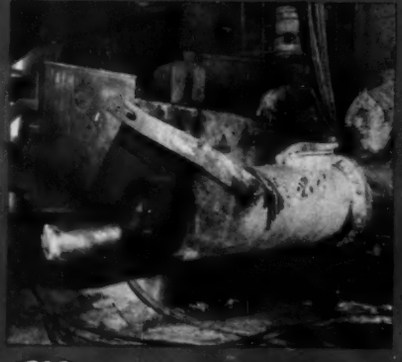


TSP 27½" x 45⅝" forged steel temper mill roll rehardened and ground and ready for further service.

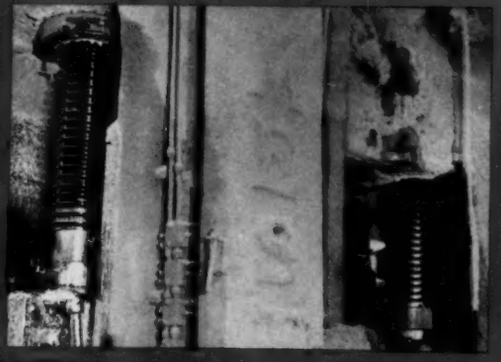


TSP leveller rolls on Hallden flying shears.

TSP leveller rolls in continuous 24 hour service on plate levellers.

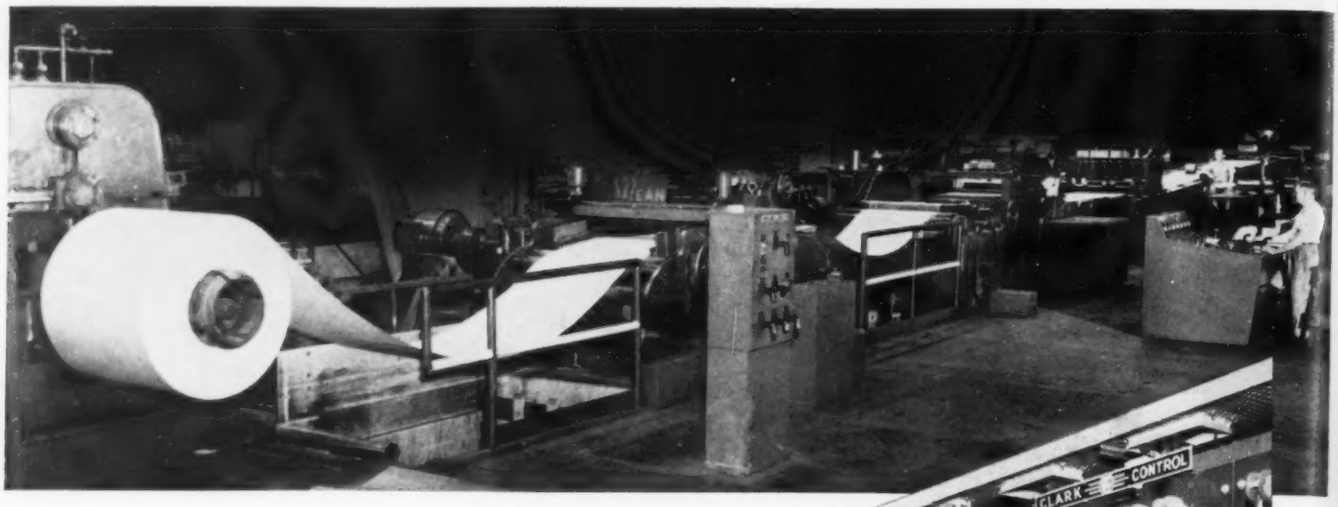


TSP screw and nut on clay gun. Service life 29 months versus 12 months for competitive material.



TSP mill screwdown screws on 40" blooming mill. Service life more than six times that of competitive screws and nuts previously used based on actual tonnage rolled.

TSP drum pinion, in service on skull cracker crane since 1943.



CLARK CONTROL at WEIRTON STEEL

(Top) Flying Shear Line

(Lower) Section of Clark Control Panel for Flying Shear Line.

48-inch Flying Shear Line and 50-inch Pickle Line are CLARK CONTROLLED

Clark provides dependable electrical control for two important processing lines at Weirton Steel Company, a division of National Steel Corporation.

The Flying Shear Line illustrated handles 60,000 pound coils of electrolytic-coated zinc steel—maximum width 48 inches, thickness to .065 inches, length of cuts from 20 inches to 13 feet, speed 350 rpm.

The 50-inch Pickle Line handles coils up to 74 inches OD—maximum width 50 inches, thickness to 0.187 inches. Exit speed is 750 fpm.

This is another example of critical processing operations in a steel mill successfully controlled by Clark engineered apparatus. Let us help you solve your control problems.

The **CLARK CONTROLLER** *Company*

Everything Under Control 1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

12 B&W IFB lined single stack annealing covers in use in the strip annealing department of Weirton Steel Company, a division of National Steel Corporation, at Weirton, West Virginia.

WEIRTON STEEL COMPANY uses lightweight B&W Insulating Firebrick for single stack annealing covers.

These 12 covers, lined with B&W K-20 Insulating Firebrick, have been in service more than two years in the annealing of low and high carbon strip from Weirton's 54″ strip mill. Identical in construction, the covers are over 17 feet from base to skew and over 10 feet in diameter. The domes are of 9″ K-20 IFB construction.

The K-20 is one of B&W's *lightweight* Insulating Firebrick. In fact, B&W K-20 IFB are at least a third of a pound lighter than other 2000 F insulating firebrick. This means savings in the overall weight of portable covers. Additional savings in fuel consumption and cycle time are possible because lightweight B&W IFB store and conduct less heat. Heat is kept in the furnace, not in the lining.

This application points out advantages of light weight in insulating firebrick constructions. And B&W makes the *lightest* weight insulating firebrick. Consult your B&W Refractories Representative for information on how you can profit with lightweight B&W IFB.

Bulletin R-2-H available on request.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS:
B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide • B&W Ramming Mixes • B&W Kaowool

R-617

WHY GUESS...

WHEN YOU CAN KNOW WITH *Diamond* HEAVY DUTY TELEVISION!

Charging operator's "third eye" shows exact clearances before he moves slabs into a reheat furnace 90 feet from the control position.

Diamond Model 400 heavy duty television camera never relaxes for a moment; presents a clear and continuous picture to the control room. It is unaffected by heat, vibration, noise, and airborne dirt that are typical of this area of steelmaking.

At National Steel Corporation's Weirton Steel plant there is no guesswork in positioning slabs for charging the reheat furnace on the end of the line. Although the operator in the charging control cupola is 90 feet away from the furnace, a *Diamond Heavy Duty Television* system lets him be there visually to see that slabs do not ram into the furnace portal. Weirton knows that a jammed portal will cost them real money not only in expensive furnace repairs, but in lost production as well. That is why Diamond television with its circuit simplicity and reliability record is considered indispensable yet inexpensive insurance against these twin costs.

Diamond

"First in Industrial Television"

DIAMOND POWER SPECIALTY CORPORATION

Electronics Division, Lancaster, Ohio

300/15-ton stripper crane with 85-ft. span.
Photo courtesy National Steel Corporation, Weirton Steel Division.

300-TON STRIPPER CRANE

One of the many built-in operating advantages of this 300-ton stripper crane installed at National Steel Corporation, Weirton Steel Division, is the use of electric counterweights . . . no added load is imposed on the ingot car as the weight of the column is balanced by the torque of the hoist motor.

The use of the electric counterweight makes it unnecessary to install heavy counterweights. Ratchet gears and auxiliary counterweights previously required to prevent slack cable may also be eliminated.

This Alliance engineering ingenuity can work for you on any heavy lift requirement. A wire, phone call or letter will bring prompt action.

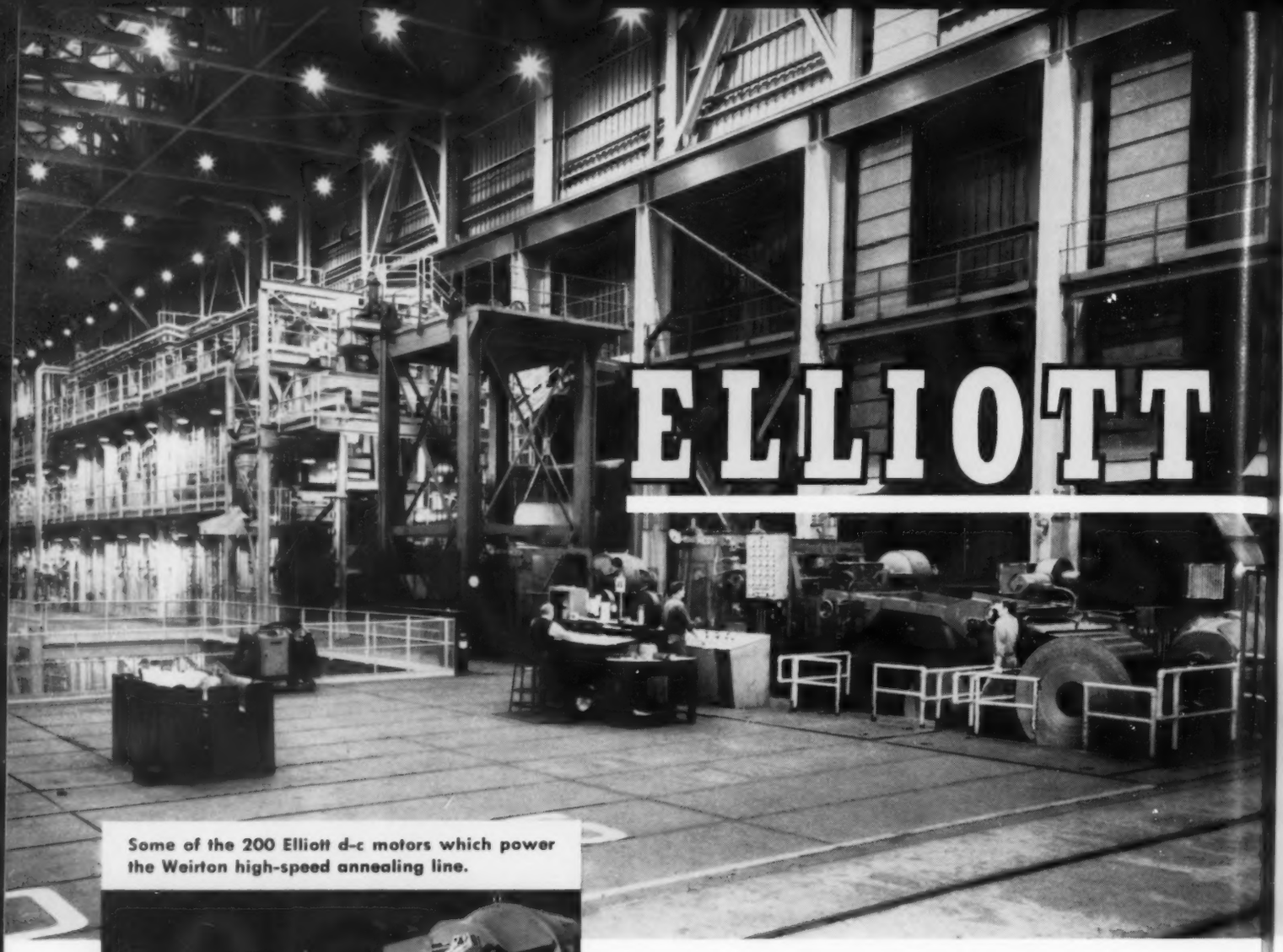
"For the greatest over-all return from your investment, specify Alliance."

THE Alliance MACHINE COMPANY

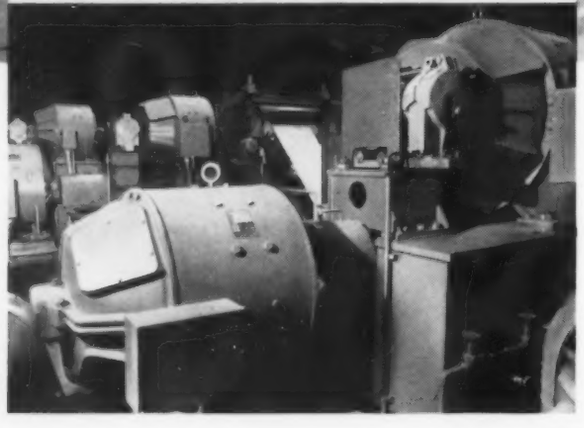
MAIN OFFICE • ALLIANCE, OHIO
Branch Office • Miami, Florida

"Give us the Runway and We'll Lift the World"

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB & BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS • LOADING & UNLOADING TOWERS

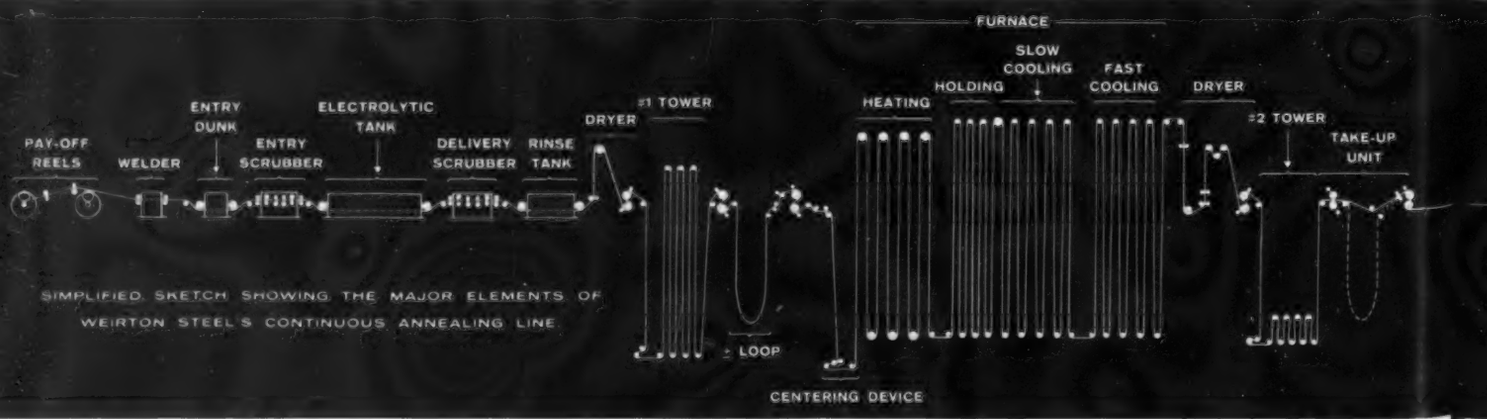


Some of the 200 Elliott d-c motors which power the Weirton high-speed annealing line.



From start to finish—

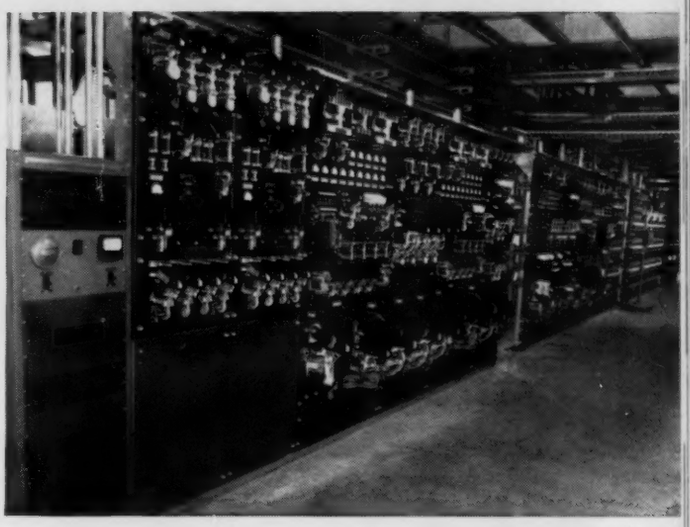
ELLIOTT equipment provides precise coordination of complex electrical drives



SIMPLIFIED SKETCH SHOWING THE MAJOR ELEMENTS OF WEIRTON STEEL'S CONTINUOUS ANNEALING LINE

(Left)
Over-all view of annealing line from delivery end. Approximately 200 Elliott motors and generators power this huge processing line.

CONTROL SYSTEM (right) was designed by Elliott Industry Engineering Department in cooperation with Weirton Steel Company engineers.



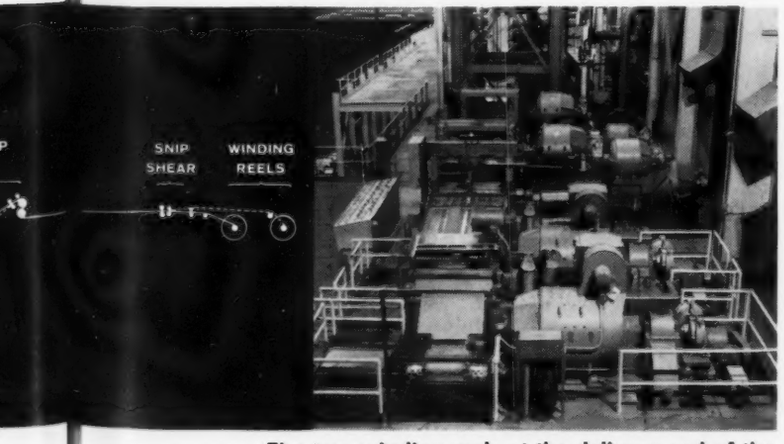
equipment drives Weirton's new high-speed continuous annealing line

HARD, brittle cold-rolled strip steel races through the new Weirton 560-foot cleaning and annealing line at record-breaking strip speeds of up to 2000 feet per minute. It emerges soft, ductile and workable. Capacity at top operating speed is 60 tons per hour.

Processing thin gage, brittle material at high speeds, and without damage or interruption, obviously requires precise coordination of the various electrical drives. Elliott supplied all of the rotating electrical equipment for this gigantic facility—including more than 200 motors and generators. The control system which achieves the necessary coordination was also designed by the Elliott Industry Engineering Department in cooperation with Weirton Steel Company engineers.

Additional Elliott steam and electrical equipment, installed at Weirton Steel Company, (a division of National Steel Corporation) over the last 40 years, includes turbine-driven blast furnace and coke oven compressors, mechanical-drive turbines, barometric condensers, deaerating feedwater heaters, and water strainers.

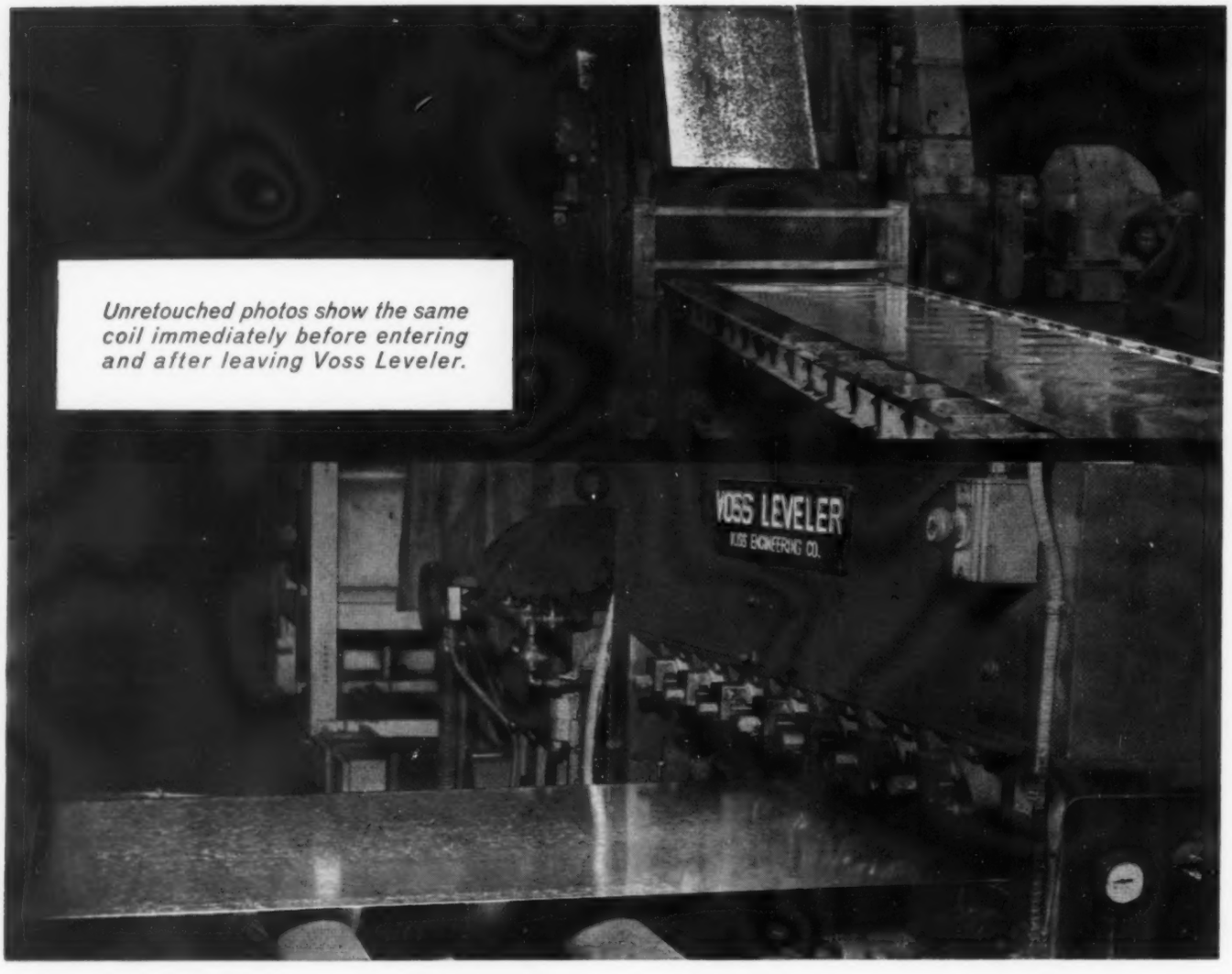
Bulletin Q-23A, "Elliott Equipment for the Steel Industry and Related Industries," illustrates many other outstanding examples of Elliott's experience in coordinating electrical drives. For your copy, address Elliott Company, Jeannette, Pa.



The two winding reels at the delivery end of the line are each driven by a 200-hp, 200/1200-rpm Elliott motor.

ELLIOTT Company

Q9-1



Unretouched photos show the same coil immediately before entering and after leaving Voss Leveler.

Better than
1000 TONS DAILY PRODUCTION
Equaling or Exceeding Stretcher-Level Flatness with VOSS ROLLER LEVELERS

This Voss Inverted Roller Leveler is one of several installed in the high speed galvanizing lines of a leading sheet producer. Operating in a range of 10 to 30 gauge, Voss Levelers are giving this producer a new standard of flatness and greatly improved non-fluting qualities. The result is a sheet or coil equal to or exceeding stretcher-level flatness . . . at top production speeds.

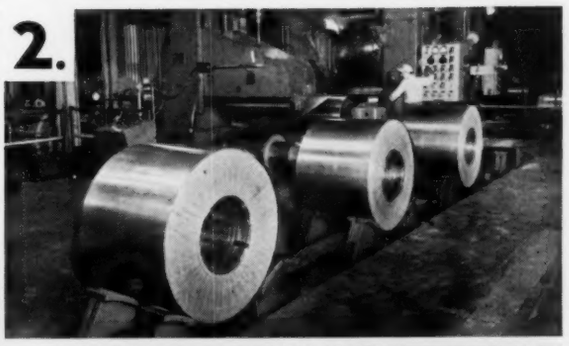
Voss-patented design features offer unusual precision and flexibility. Work rolls are backed by a multiple system of individually adjustable back-up rollers, and, combined with simultaneous roll bend and longitudinal and radial tilt, provide area pressure control on any section of the work. Compact and trouble-free, Voss Roller Levelers are engineered to level hot or cold-rolled sheet, coil, strip or plate as well as non-ferrous metals. Let us demonstrate the advantages leading steel producers are enjoying through the use of Voss Inverted Roller Levelers.

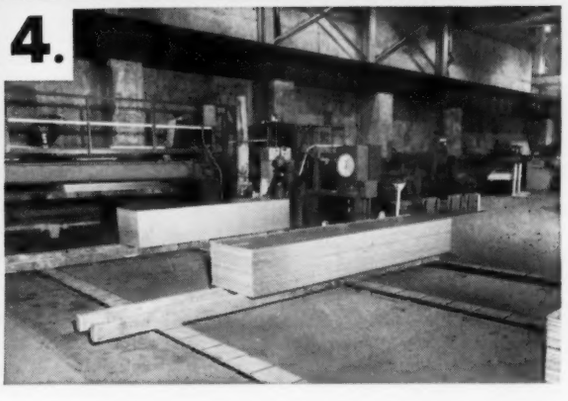
Voss ENGINEERING CO.

7301 Penn Ave. Pittsburgh 8, Pa. Churchill 2-4422

Raw materials to finished products...it's LINK-BELT conveyors

ALL THE WAY AT WEIRTON





System handles iron ore, sinter, coils and sheets

From basic raw materials to finished steel products, Link-Belt conveyors help modern mills such as Weirton boost yield, cut waste, improve safety.

In furnishing complete, high-capacity bulk handling systems for both new and expanding mills, Link-Belt helps to solve problems of storing and reclaiming ores, coke, stone, pellets and sinter.

For steel in every form, Link-Belt conveyors handle large tonnages dependably, yet gently enough to reduce damage and scrap losses. And by limiting crane movements and eliminating travel of vehicles near crews, your operation is safer too.

Whether you're planning a new plant or modernizing, get in touch with your nearest Link-Belt office.

1. **RECLAIMING IRON ORE FROM STOCKPILE** — This 1300-ft. long belt conveyor is equipped with Link-Belt idlers and has a capacity of 1200 tons per hour. A Link-Belt belt conveyor blends sinter mixes inside sinter plant.

2. **TRANSPORTING AND STORING STEEL COILS**—Link-Belt two-strand saddle-type conveyor provides storage and indexing of coils ahead of temper mill. Similar conveyor operates at delivery end.

3. **TRANSFERRING STEEL COILS** — Link-Belt two-strand coil conveyor and tilter move coils weighing up to 60,000 lbs. from mill floor to shipping room floor or to anneal in another bay.

4. **PILING PRIME SHEETS (FINISHED PRODUCT)**—Link-Belt three-strand roller chain conveyor receives 15,000-lb. piles of sheet.

LINK-BELT

MATERIALS HANDLING, PROCESSING
& POWER TRANSMISSION MACHINERY

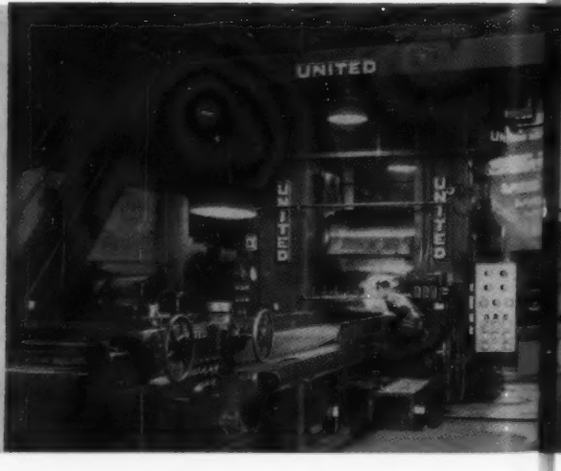
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,966

26" & 49" x 54"—4 High Hot Strip Mill

United Mills and Equipment Designed and B

26" x 46"—2 Stand Tandem Temper Pass Mill

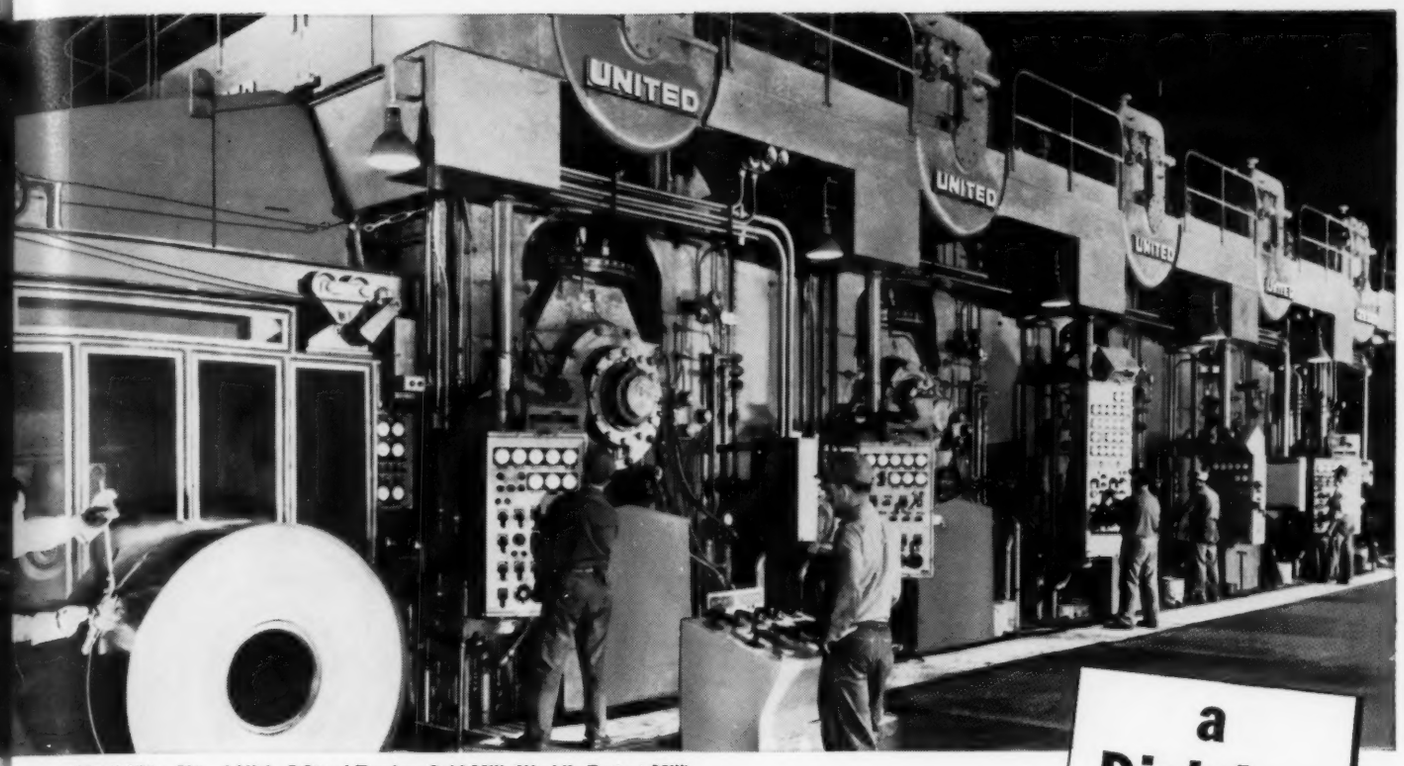
20" & 49" x 54" 4 High Temper Pass Mill



UNITED® ENGINEERING

AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

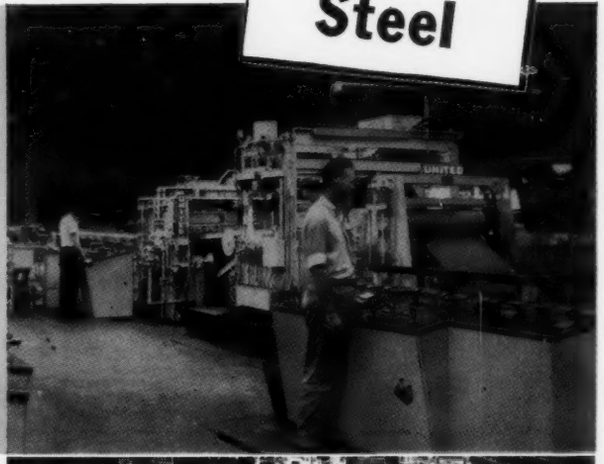


23" & 56" x 52"—4 High, 5 Stand Tandem Cold Mill (World's Fastest Mill)

Built for Weirton Steel Company

a Division of National Steel

21" & 53" x 42"—
4 High, 5 Stand
Tandem Cold Mill
(First "Mile-a-Minute Mill")



38" Electrolytic
Cleaning Line

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other Heavy Machinery. Manufacturers of Iron, Nodular Iron and Steel Castings, and Weldments.

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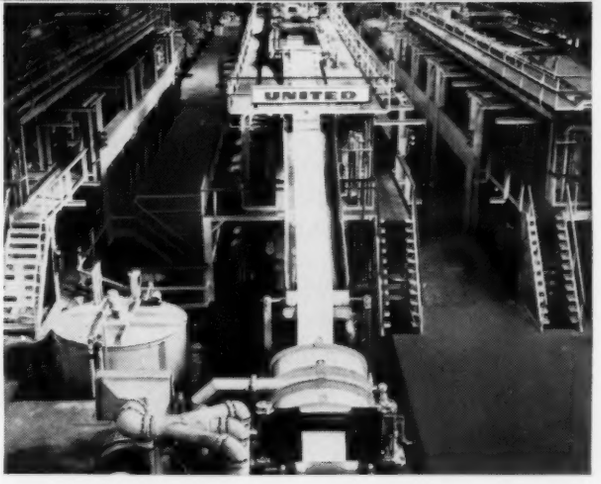
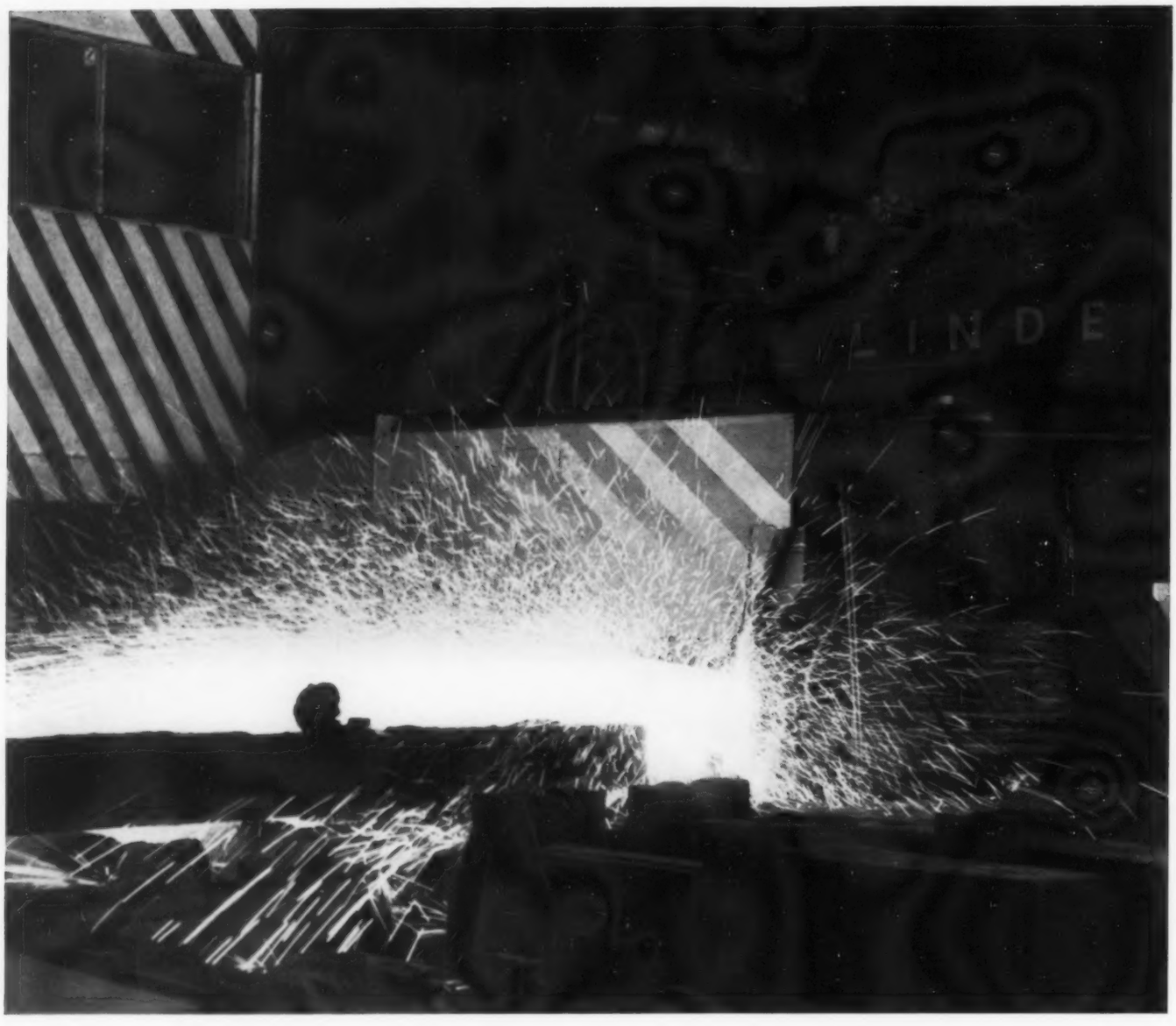


Electrolytic
Coating Lines



LIN-DE-SURFACER MACHINE HOT-SCARFS 4.27 MILLION TONS IN 27 MONTHS

Weirton Steel Company, Division of National Steel Corporation, set the record. Of the 65 *Lin-de-Surfacer* machines serving steel plants throughout the world today, this is the champ—4.27 million tons in just 27 months.

Mechanized scarfing is the fastest, most economical way to upgrade surface quality. Your costs depend on your production because you lease the *Lin-de-Surfacer* machine on the basis of the tonnage it processes. It can be rolled on or off the production line in seconds. Scarfing speeds can reach 195 ft./min.

And—most important—savings over hand-conditioning methods are estimated conservatively at $1.50 per ton—are often much higher.

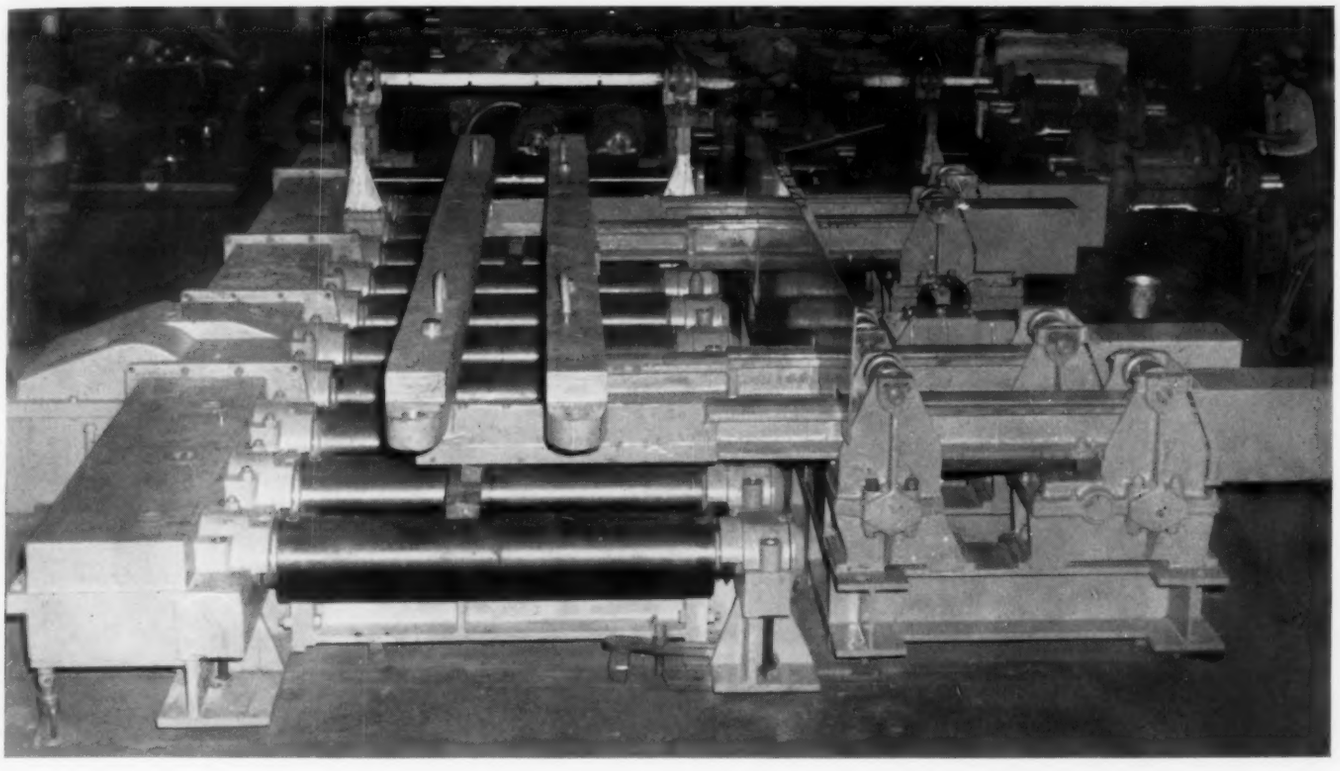
"Linde," "Lin-de-Surfacer," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Linde Company—a leader in the production and distribution of oxygen and acetylene—pioneered the development of mechanized scarfing. To find out how hot-scarfing can help your operations, call the nearest Linde office. Or write Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde TRADE-MARK

UNION CARBIDE

Treadwell



Slab Centering Equipment, designed and manufactured by Treadwell for installation at Weirton Steel Co., Div. of National Steel Corp.

This sturdy table and manipulator were designed for use on Weirton's Blooming Mill tables in conjunction with the recently installed automatic scarfing equipment.

BETTER GRADE MACHINERY

Treadwell Engineering Company

EASTON, PA.

SALES AND ENGINEERING OFFICES:

208 S. LA SALLE STREET	140 CEDAR STREET	1015 FARMERS BANK BLDG.
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Reliance drive gives Weirton shear line

flexibility, accuracy

A Reliance Engineered Drive powers Weirton's 42 inch shear line. A total of 185 horsepower provides not only the brute strength, but the flexibility and rapid response required for this cut-to-length operation.

Twenty-ton coils of zinc coated steel are accurately cut in lengths varying from one to 13 feet, thanks to the delicate coordination of line sections by the Reliance Drive.

For accuracy and coordination to go with your horsepower, call on Reliance. Trained Reliance Application Engineers, experienced in steel mill operations are ready to work on your drive problems. L-1606

MASTER REEVES

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 1111A1, CLEVELAND 17, OHIO
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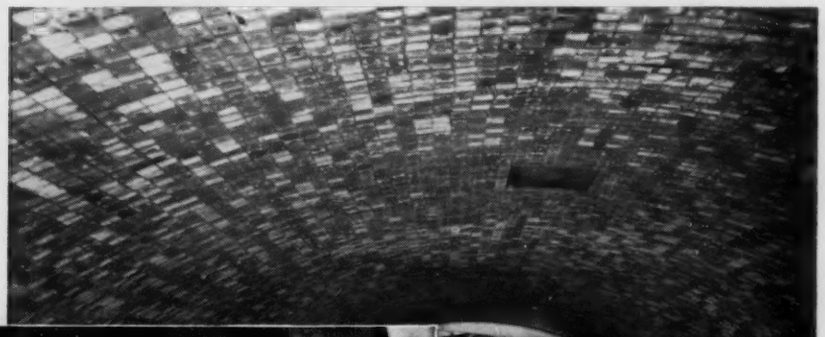
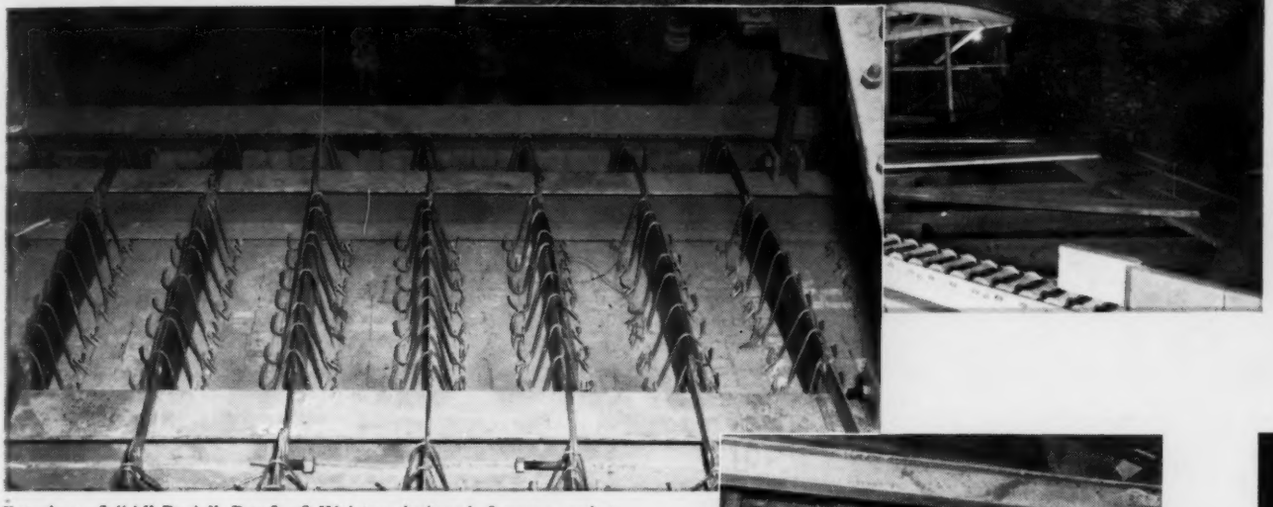
GREFCO

SALUTES...

Interior of Weirton-designed "All-Basic" furnace, with roof of STEELKLAD 40-EE "Tab" brick.





Exterior of "All-Basic" Roof of Weirton-designed furnace, using STEELKLAD 40-EE "Tab" brick.

WEIRTON STEEL

for "All-Basic" Steelmaking

Weirton Steel Company, a division of the National Steel Corporation, is one of the leaders in technological steelmaking advances. Part of this leadership is shown by these photographs of new "All-Basic" furnace installations at Weirton, including one of the largest open hearth furnaces on the American Continents.

These "All-Basic" furnace installations, especially tailored and designed by Weirton for ultimate economy and ease of construction, are built with GREFCO basic brick. All suspended construction utilizes either "Tab" or "Ferroclip" hangers, and all the brick are "STEELKLAD-A", "STEELKLAD-40" or "STEELKLAD 40-EE".

GREFCO is proud to have contributed to these notable advances in open hearth furnace construction.

View of Basic End showing pit side wall above slag pocket seal. Weirton-designed construction using GREFCO STEELKLAD-40 "Ferroclip" brick.

Detail of chill wall construction in Basic End designed by Weirton, using GREFCO STEELKLAD-40 "Tab" brick.

GENERAL REFRACTORIES COMPANY
Philadelphia 2, Pa.

A COMPLETE REFRACTORIES SERVICE

GENERAL REFRACTORIES

Modernization of Weirton Coal Handling Facilities was completed without Shut Down of Operations.

Engineering, construction and installation of equipment for the modernization and expansion of the coal handling system at Weirton Steel Company Division of National Steel Corporation were handled by Roberts & Schaefer.

The system includes conveyors, storage bins and complete crushing, screening and weighed blending facilities. Old buildings were enlarged. New buildings were constructed. Old conveyors and other equipment were rebuilt. Extensive additions to existing equipment were made. The entire project was completed with a minimum of interference with production and no shut down of operations . . . another R&S creative engineering job.

ENGINEERS & CONTRACTORS

ROBERTS & SCHAEFER Company

130 NORTH WELLS STREET, CHICAGO 6, ILLINOIS

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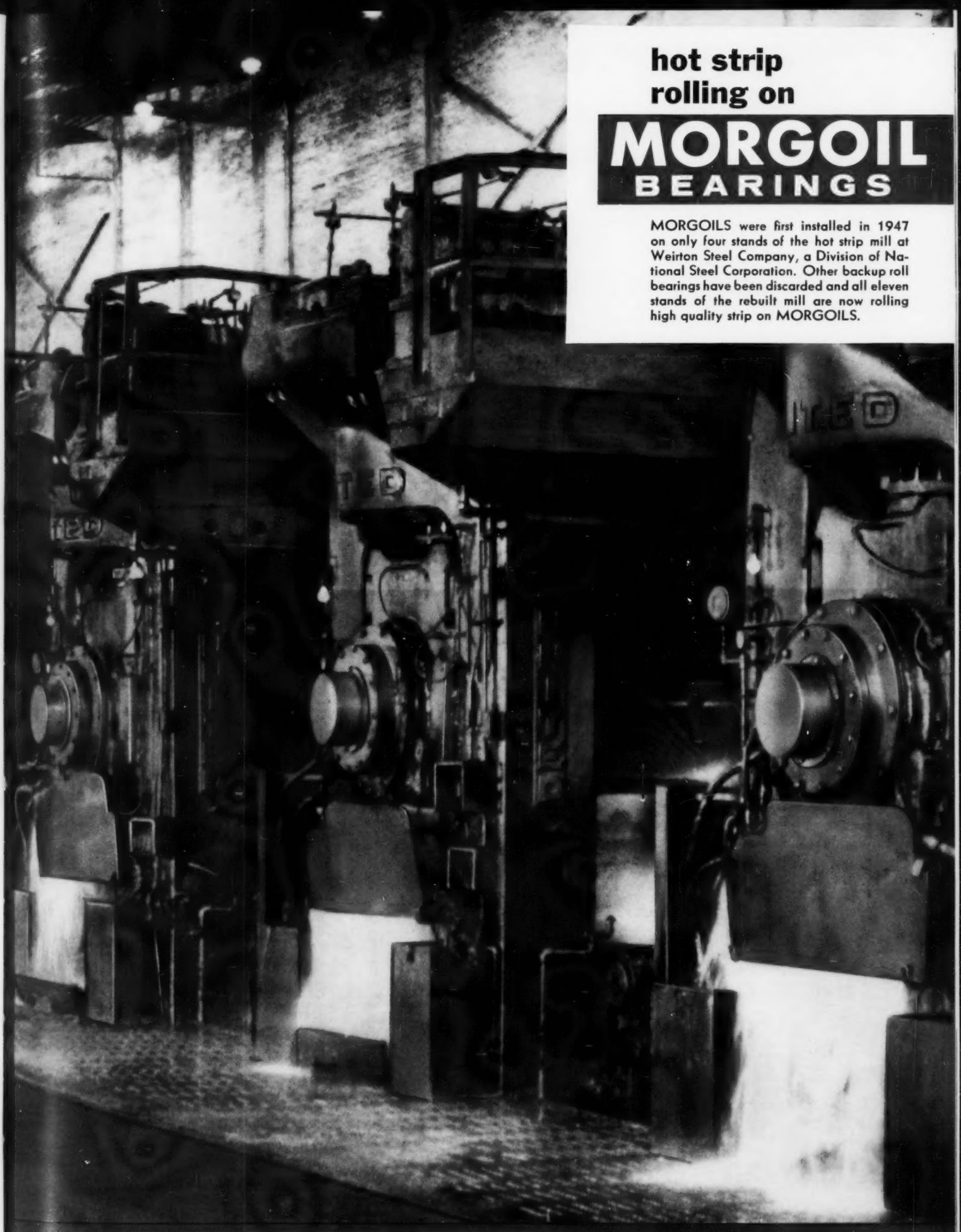


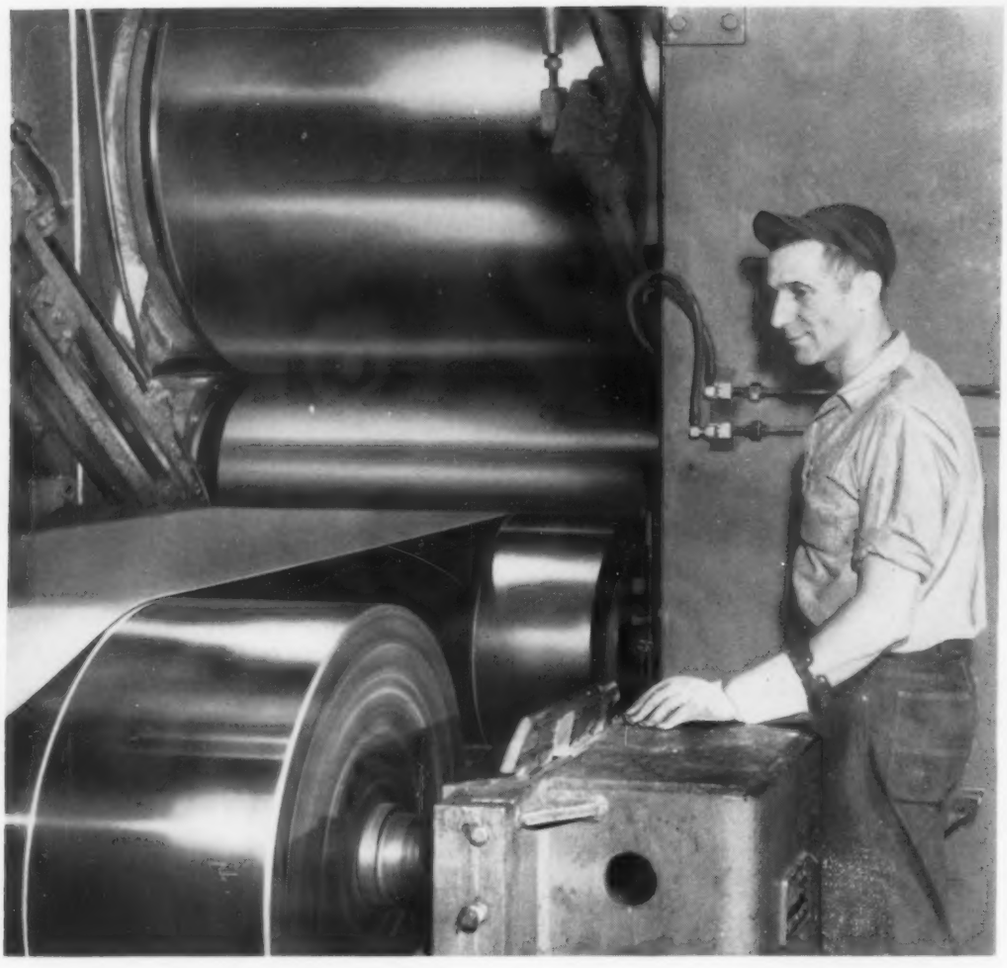
hot strip rolling on MORGOIL BEARINGS

MORGOILS were first installed in 1947 on only four stands of the hot strip mill at Weirton Steel Company, a Division of National Steel Corporation. Other backup roll bearings have been discarded and all eleven stands of the rebuilt mill are now rolling high quality strip on MORGOILS.

MORGAN CONSTRUCTION CO., WORCESTER, MASSACHUSETTS

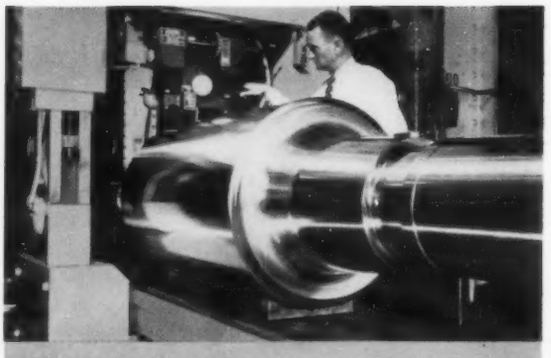
ROLLING MILLS • MORGOIL BEARINGS • GAS PRODUCERS
WIRE MILLS • EJECTORS • REGENERATIVE FURNACE CONTROL

MB 35



Recognized extra quality for over 30 years

UNION Forged Steel Rolls have been an integral part of cold rolling operations at Weirton Steel Division of National Steel Corporation for 31 years. Such continuity of use is indicative of the *consistent* high quality furnished by Union rolls from roll-to-roll and year-to-year. Precise quality control is the answer—a literal guarantee of the roll characteristics which have made Union Forged Steel Rolls favorites in most of the cold rolling mills of the world.



ACCURATE HARDNESS—Rockwell indentation hardness testing is relied upon to assure consistent quality at Union.

CONTROLLED HEAT TREATING—Rows of continuous recording temperature controls guard heat treating temperatures in every furnace zone.

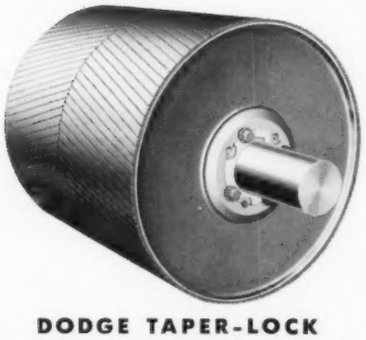
UNION

FORGED STEEL ROLLS

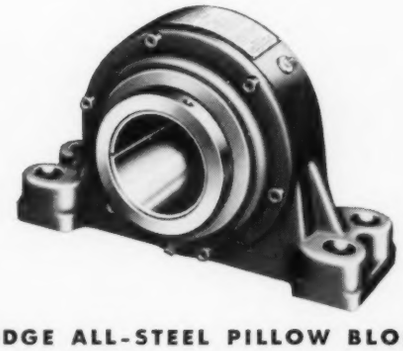
UNION ELECTRIC STEEL CORP.

OLIVER BUILDING PITTSBURGH, PA.

DODGE STEEL CONVEYOR PULLEYS • DODGE STEEL PILLOW BLOCKS CHOSEN FOR WEIRTON'S NEWEST CONVEYOR SYSTEM



DODGE TAPER-LOCK STEEL CONVEYOR PULLEYS



DODGE ALL-STEEL PILLOW BLOCKS WITH TIMKEN BEARINGS

Two of the most dependable products known in the field of mechanical power transmission are used to insure the uninterrupted flow of material in the new plant of Weirton Steel Company division of National Steel Corporation. Dodge Taper-Lock Steel Conveyor Pulleys and Dodge All-Steel Pillow Blocks with Timken Bearings, were chosen for the entire system of belt conveyors—designed and installed by Koppers Company, Inc., Engineering and Construction Division.

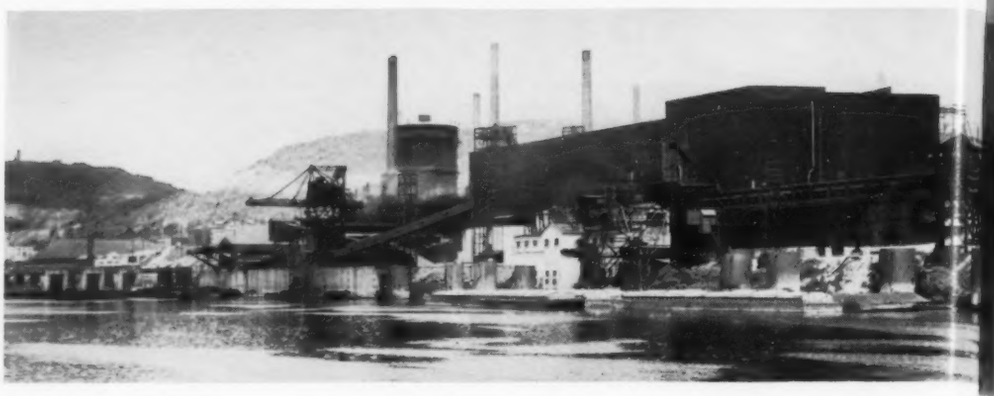
Maximum strength with minimum weight is provided by Dodge Conveyor Pulleys. The steel rims, discs and hubs are fused together into jointless drum construction for terrific impact resistance. And with the unsurpassed holding power of Taper-Lock mounting there is no "walking on the shaft."

Dodge All-Steel Pillow Blocks are expressly designed for industry's toughest jobs. They are rugged, compact, fully self-aligning—with *high* radial and thrust capacities. And they are permanently adjusted, lubricated and sealed at the factory—for a long life of dependable service.

DODGE MANUFACTURING CORPORATION
5900 Union Street, Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."



WEIRTON STEEL COMPANY

DIVISION OF NATIONAL STEEL CORPORATION

By T. J. Ess

JUST ten years ago, when the *Iron and Steel Engineer* was first privileged to publish a description of the plant of Weirton Steel Co., principal annual capacities were 1,400,000 tons of by-product coke, 1,240,000 tons of iron and 1,950,000 tons of steel ingots. Today, after numerous construction projects costing many millions of dollars, these capacities are reported as 1,900,000 tons of coke, 2,300,000 tons of iron and 3,300,000 tons of steel ingots. Thus, this plant has continued the uninterrupted growth that has marked it since its inception in 1909. Concurrent with this growth, there has been a constant program of modernization that has kept Weirton among the more efficient operators in the industry.

Gradually, the product mix of Weirton has centered on strip products, with some structural shapes, the hot rolled capacities now consisting of 2,415,000 tons per year of coils for sheet, black plate and tin plate, and 200,000 tons of heavy structural shapes. The company is the largest independent producer of tin plate.

At present, the plant site consists of 350 acres in an arc-shaped valley tipped at each end by the Ohio River. At the upper intersection are the river docks, coke ovens and tin mill, followed by the blast furnaces, open hearth, blooming mill, structural mill, sheet mill, and at the lower end, the strip mill.

COKE PLANT

The parent company, National Steel Corp., operates coal properties in Fayette, Allegheny and Washington counties, Pennsylvania. Coal for Weirton is washed at the mines and loaded into barges for shipment down Monongahela and Ohio Rivers. Table I shows analyses of coals used at Weirton.

Arriving at Weirton, coal is unloaded by two tower hoists capable of handling 750 tons per hour. Belt conveyors move the coal to a breaker building, from where it may pass to the mixer building for immediate use in the ovens or to a storage yard. Coal is reclaimed from this ground storage by a traveling tower at a rate of 500 tons per hr.

TABLE I
Coal Analyses

	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur
Renton	5.4	37.5	54.8	7.7	1.46
Isabella	8.4	36.8	54.9	8.3	1.36
Mathies	6.3	38.3	55.1	7.0	1.48
Hubbard	5.3	36.4	56.9	6.7	1.25
Pocohontas	5.9	16.5	76.3	7.2	0.60

Two 300-ton per hr breakers crush the coal as received, which is carried by belt conveyors to the mixer building and then on to the oven bins. A typical coal mix consists of 28 per cent Isabella, 34 per cent Mathies, 20 per cent Renton and Hubbard, and 18 per cent Pocohontas. These coals are blended as desired and

Coking coal comes to Weirton principally by barge. It is unloaded by two tower hoists and moved to a breaker building or to storage.

THOMAS MILLSOP
President
National Steel Corp.

EDWIN O. BURGHAM
Chairman
Weirton Steel Co.

ALBERT J. BERDIS
President
Weirton Steel Co.

CHARLES E. CARR
Vice President—Operations
Weirton Steel Co.

TABLE II
Coke Oven Data

Battery No.	4	5	6	7	8	9
Year built	1942	1947	1947	1951	1954	1956
No. of ovens	45	53	53	61	41	41
Oven width, pusher side, in.	15½	15¼	15¼	15¼	15¼	15½
Oven width, coke side, in.	18½	18¾	18¾	18¾	18¾	18½
Taper, in.	3	3½	3½	3½	3½	3
Oven length, ft-in.	40-5½	40-6½	40-6½	40-6½	40-6½	40-6½
Oven height, ft-in.	13-0	13-0	13-0	13-0	13-0	13-0
Oven volume, cu ft	688	689½	689½	689	689½	689½

then crushed by two 400-ton per hr pulverizers so that 50 per cent passes through a ⅛-in. mesh.

There are now 294 by-product coke ovens, arranged in six batteries. Oven proportions are given in Table II. All of these ovens take an 18-ton coal charge, and are of underjet design, heated by coke oven gas or by blast furnace gas with enriching jets of coke oven gas. Normally, coking time averages about 16.5 hr, net, giving about 404 ovens pushed per day.

Three of the batteries are located in one line, while the other three form another line at about 45 degrees to the others. Two pushers, one quench car, and one quenching tower serve each group of batteries.

After quenching and cooling, oven coke is conveyed to the screening station, where shaker screens separate furnace coke (over 1 in.), pea coke (⅝ in. to 1 in.) and breeze (under ⅝ in.). A belt conveyor moves furnace coke to the blast furnace high line, where railroad cars move it to the furnace coke bins.

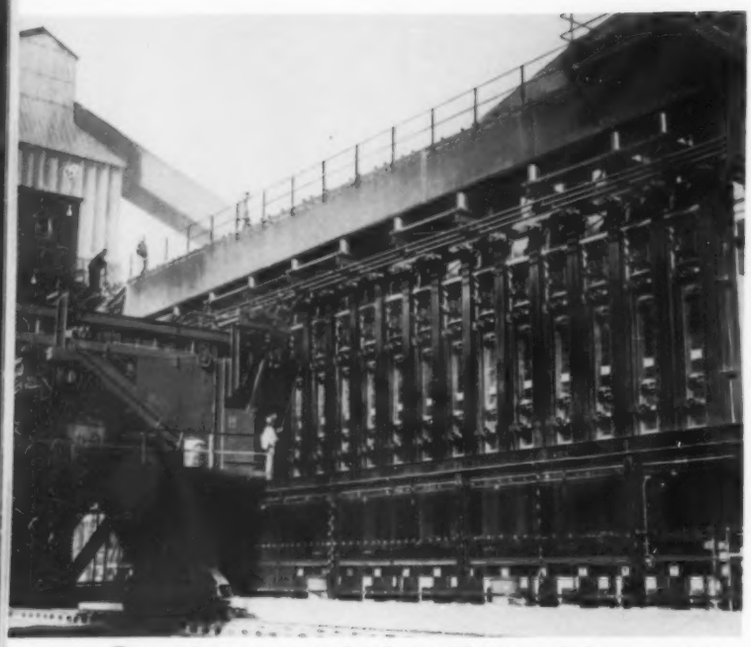
By-product equipment for the recovery of tar, ammonium sulphate and crude light oil includes three direct type primary coolers, five centrifugal exhausters, four boosters, five electric precipitators, two vacuum type absorbers, three spray type final coolers and five scrubbers with metal spiral packing, where wash oil absorbs the light oil from the gas. There is also an ammonium sulphate recovery system using continuous centrifuges, forced drying, and conveying system.

Light oil is recovered, purified and fractionated in the benzol plant which contains two wash oil stills and purifiers, a rectifier, two continuous CS_2 columns, two batch-type agitators, and two batch-type pure stills. The light oil is separated into benzol, toluol, xylol and intermediate fractions.

A new phenol recovery plant uses counter-current flow in two centrifugal extractors, eliminating the necessity for towers.

The coke plant carbonizes 7300 tons of coal per day and produces 5250 tons of furnace coke per day. Coke yields average 71 per cent furnace coke, one per cent pea coke and four per cent breeze. Coke contains about ten per cent ash, one per cent sulphur and 0.9 per cent

This traveling tower handles coal into and out of storage.



By-product ovens each take an 18-ton coal charge and normally operate on a 16.5-hr net coking time.

volatile matter. By-product yields average 9.7 gal of tar, 19 lb of ammonium sulphate and three gal of light oil per ton of coal coked. Gas make runs about 12,000 cu ft per ton of coal, which, after deducting usage in the enriching jets of the oven heating system, gives about 9800 cu ft of surplus gas per ton of coal for use in steel plant heating operations.

BLAST FURNACES

Iron ore for Weirton comes from company-owned mines in the Mesabi and Old Range fields in Minnesota, Michigan and Wisconsin, and from the Labrador-Quebec field, in which the company has an interest. Analyses of these ores are given in Table III. Lake ores are graded at the head of the lakes.

Lake ore comes to the plant by rail from the lower lake ports. Laborador ore is shipped from Seven Islands by water to Philadelphia, from where it proceeds by railroad. Cars may be moved directly to the high line above the blast furnace stock bins or to a car dumper which unloads directly into No. 1 ore yard or into a transfer car for storage in No. 2 and 3 ore yards. No. 1 yard is 240 x 1160 ft, holds 925,000 tons of ore and is served by two 10-ton bridges. No. 2 yard, 261 x 500 ft, holds 350,000 tons and has one 10-ton bridge, while No. 3 yard, 261 x 538 ft with one 10-ton bridge, will store 450,000 tons. The bridges reclaim material from storage, and place it in transfer cars for transportation to the stock bins or on conveyors, leading to the sinter plant. Ore is crushed and screened, with fines being moved by conveyor to the sintering plant.

Limestone comes by rail from the Columbus and Cleveland areas in Ohio, and may also be stored in the ore yard. It is specified to be sized $1\frac{1}{2}$ x $3\frac{1}{2}$ in. Typical analyses are shown in Table IV.

Ore and limestone are moved from the stock bins to the skip cars by 15-ton scale cars. Coke is discharged from the coke bin directly into the skip cars, being screened and weighed in the process.

Four modern blast furnaces provide iron-making capacity of about 6500 tons per day. Proportions of these furnaces are given in Table V.

The furnaces are cooled by cast iron staves in the hearth jacket, by 12 rows of copper cooling plates from the hearth jacket up to the mantle, and by nine rows of plates above the mantle. Steel wearing plates set into the lining protect the stock line section.

All four furnaces have carbon block bottoms 3 ft-9 in. thick, with carbon block walls in the crucible up to the cinder notch. Under the carbon bottoms are six courses (9 ft) of first quality firebrick. On the more recent relines, one or two of these courses are of cone No. 18 quality.

Each furnace is charged by a conventional double skip dumping into a rotating distributor top. Bells are operated through levers and cables by pneumatic cylinders. Automatic charging control is provided for each furnace. The usual charging sequence is ore, ore, stone, coke, coke.

Of the three ores listed in Table III, the ore mix, direct to the furnaces and to the sinter-plant, generally consists of 20 per cent Hanna ore, 30 per cent Weir ore and 50 per cent Labrador ore. This gives an average raw ore charge containing about 52 per cent iron, 7.07 per cent silica, 0.178 per cent phosphorus, 0.71 per cent manganese, 1.81 per cent alumina, and 9.85 per cent moisture. Sintering increases the iron content to about 56 per cent or more. Since the start of the new sintering machine, the proportion of sinter has been gradually stepped up toward 60 per cent of the ore charged.

Blast for the furnaces is provided by six 30-psi turboblowers, one rated at 65,000 cfm, three at 75,000 cfm and two at 90,000 cfm. All are equipped with barometric condensers. Blast to each furnace averages about 75,000 cfm, with pressure at the tuyeres running 17 to 18 psi.

Blast is heated in stoves as listed in Table V. Checkerwork in the stoves is of two types, one with 2-in. flue openings, one with $5\frac{1}{4}$-in. flues with inserts. The stoves are operated two hours on blast before changing. Blast temperatures are controlled by automatic mixer valves and range from 1100 to 1650 F. Moisture content of the blast is also controlled automatically. This may vary over a wide range, but averages about 18 gr per cu ft. Stoves consume about 22 per cent of the blast furnace

TABLE III
Iron Ore Analyses

Range	Ore	Per Cent					
		Iron	Silica	Phosphorus	Manganese	Alumina	Moisture
Mesabi	Hanna	50.60	10.20	0.075	0.60	1.85	10.25
Menominee	Weir	51.80	5.50	0.417	0.45	2.81	8.50
Labrador	...	52.50	6.75	0.075	0.90	1.20	10.50

TABLE IV
Limestone Analyses

	Marble Cliff	Chemstone
SiO_2	1.86	1.28
Al_2O_3	0.18	0.15
CaO	50.39	45.00
MgO	3.58	8.81
S	0.033	3.01
Fe	0.30	0.20

gas produced. Gas and air for heating the stoves are proportioned by pressure burners under automatic control.

Furnace top pressure is normally 50–55 in. water column and top temperature averages about 325 F. Gas analysis varies somewhat, depending on whether the blast is enriched with oxygen:

	Normal	*With O_2 on furnace*
CO_2	15.8	14.8
CO	25.9	28.2
H_2	3.3	4.9
N_2	55.0	52.1
Btu per cu ft	94.2	106.7
CO: CO_2 ratio	1.64	1.90

Gas, containing about 22 gr of dust per cu ft, leaves the furnace top through four 4 ft-6 in. offtakes in each bell cone, and from each furnace is led through a dust catcher, a whirler and a wet washer, which reduce the dust content to about 15 gr per cu ft.

Iron ore for storage in No. 2 or No. 3 ore yards is dumped from cars into a special 100-ton side-dump transfer car.

Each furnace also has two electrostatic precipitators, through which flows gas for the stoves and boilers. On No. 1, 2 and 3 furnaces, gas connections ahead of the precipitators take off gas to be used for underfiring coke ovens and for soaking pit fuel. This gas then passes through four disintegrators. Following these, gas for the coke ovens is put through another electrostatic

Iron ore is reclaimed from storage by bridges with integral hoppers which feed onto a belt conveyor. The belt carries ore to the sinter plant or to a stationary hopper which can feed transfer cars for movement to the furnace stock bins.

TABLE V
Blast Furnace Data

Furnace No.	1	2	3	4
Diameter of hearth, ft-in.	25-6	25-6	25-6	25-6
Diameter of bosh, ft-in.	28-6	28-6	28-6	28-6
Diameter of stockline, ft-in.	19-6	19-4	19-6	19-6
Height of crucible, ft-in.	13-3	13-3	13-3	13-3
Height of bosh, ft-in.	11-0	11-0	11-0	11-0
Height of straight section, ft-in.	2-6	2-6	7-3	7-3
Height of inwall section, ft-in.	53-3	53-3	54-0	54-0
Height of stockline section, ft-in.	8-6	8-6	9-6	9-6
Height, iron notch to top ring, ft-in.	91-6	92-0	100-0	100-0
Height, bottom to iron notch, ft-in.	3-6	3-6	3-6	3-6
Height, iron notch to cinder notch, ft-in.	4-8	4-8	4-8	4-8
Height, cinder notch to tuyeres, ft-in.	3-4	3-4	3-4	3-4
Bosh angle, deg-min.	82-14	82-14	82-14	82-14
Inwall batter, in. per ft	1 1/64	1 1/32	1	1
Working volume, cu ft	34,676	34,676	38,224	38,244
No. of tuyeres	16	16	16	16
Tuyere diameter, in.	6 1/2	6 1/2	6 1/2	6 1/2
Diameter of large bell, ft-in.	14-6	14-2	14-6	14-6
Angle of large bell, deg	52	52	52	52
Thickness, crucible lining, in.	31 1/2	31 1/2	31 1/2	31 1/2
Thickness, bosh lining, in.	27	27	27	27
Thickness, stack lining, in.	49 1/2	54	49 1/2	49 1/2
Thickness, stockline lining, in.	45	45	40 1/2	40 1/2
No. of offtakes	4	4	4	4
Offtake diameter, ft-in.	4-6	4-6	4-6	4-6
No. of stoves	4	3	3	3
Stove diameter, ft-in.	(3) 22-0 (1) 25-0	25-0	26-0	26-0
Stove height, ft-in.	100-0	118-0	110-0	110-0
Heating surface per stove, sq ft	(3) 146,537 (1) 182,928	202,643	211,070	241,429

precipitator. The fine-cleaned gas has a dust content of 0.01 gr per cu ft. Normal blast furnace gas usage is 22 per cent to the stoves, 59 per cent to the boilers, 13 per cent to the coke ovens and six per cent to the soaking pits. A 1,000,000-cu ft gas holder is provided on the blast furnace gas system supplying gas for coke oven heating.

Effluent from the wet washers and disintegrators flows to two thickeners, 80 ft in diam, where sludge settles out and is filtered and reclaimed for use in the sintering plant.

The blast furnaces use 3480 lb of iron ore, 1600 lb of coke and 500 lb of limestone (plus lime in sinter) per net ton of iron produced. About 425 lb of miscellaneous metallics per ton of iron is also charged, including furnace scrap, roll scale, cinder and flue dust. Only basic iron is produced, averaging about 1.12 silicon, 0.031 sulphur, 0.291 phosphorus and 0.93 per cent manganese.

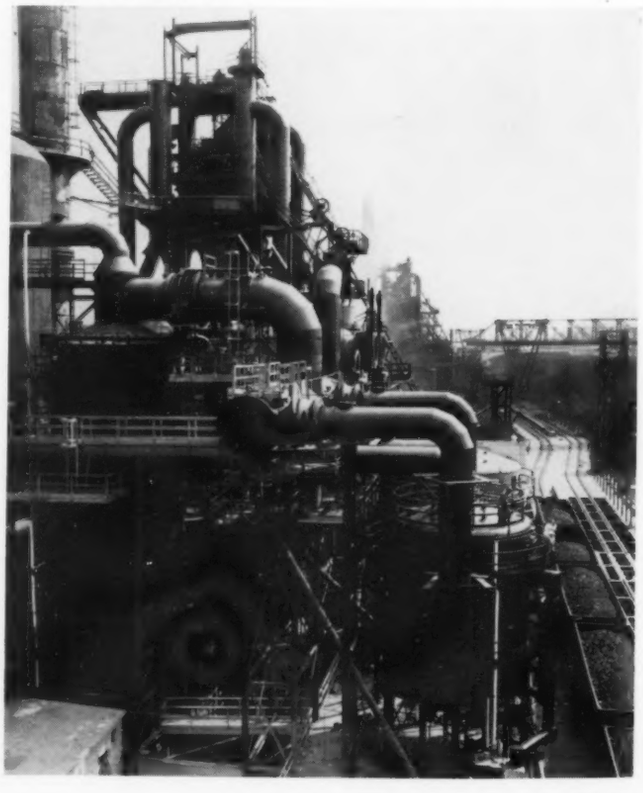
Furnaces are cast every 4 hr into open top ladles of 65 or 85 tons capacity for transfer to the open hearth and bessemer converters. About 60 per cent of the iron goes to the converters, 40 per cent to the open hearth. A double-strand pig machine is installed to pig iron that is not to be used hot.

The furnaces make about 850 lb of slag per ton of iron produced. Slag is run into cinder ladles and taken to slag pits for processing by an outside company. Slag analyses run somewhat as follows:

	High magnesia	*Low magnesia*
SiO_2	35.11	36.22
Al_2O_3	11.97	11.67
CaO	41.02	44.11
MgO	9.60	5.84
S	2.26	2.11

Flue dust averages 158 lb per ton of iron produced. This, together with fine ore from the ore yard, is processed in two sintering machines, one (an 8 x 104-ft unit) rated at 2500 tons per day, the other at 6000 tons per day. Completely self-fluxing sinter is the goal for these units. The large machine is new and is one of the

All four blast furnaces have 25-ft 6-in. hearths. Blast is enriched with oxygen and about 60 per cent of the ore charge is sintered.



largest in the steel industry. It is 12 ft wide x 147 ft long, and includes many new features. The plant has 14 storage bins ranging up to 600 tons capacity each, where fine iron ore, coke breeze, coke dust, limestone, flue dust and sinter fines are stored. These materials, controlled to the desired proportions, are mixed in a primary pug mill and a secondary balling drum and charged to the sintering machine. Ignition of the bed is effected by a radiant type furnace rather than by direct firing.

There are 14 double windboxes under the traveling grates, with two fans giving a total capacity of 512,000 cfm at 350 F drawing air down through the sinter bed.

At the end of the sinter line, sinter drops off the pallets and goes to a pallet type cooler 10 ft wide x 147 ft long, where it is cooled below 200 F. The cooling unit has 14 wind boxes and two fans, each rated at 258,000 cfm.

After cooling, sinter is screened and conveyed by belt to storage hoppers and then by transfer car to the blast furnaces.

To prevent air pollution, eight centrifugal dust collectors, each rated at 64,000 cfm, remove dust from the air drawn down through the bed. A 60,000-cfm collector is installed at the discharge end of the machine, a 75,000-cfm collector at the hot sinter screens, and a 10,000-cfm unit at the cold sinter screen.

Water from these collectors flows to the blast furnace thickeners.

Weirton has used oxygen to enrich blast for the blast furnaces to a greater extent than any other plant in the United States, starting in 1951. They have increased oxygen in the blast by one to four per cent (1200 to 4500 cu ft of oxygen per ton of pig iron) and have obtained increased iron production and smoother working furnaces.

The effect of increasing oxygen in the blast is somewhat as follows:

	Tons of iron per day
2 per cent O_2 added	1450
3 per cent O_2 added	1600
4 per cent O_2 added	1700

They have also found that the use of oxygen requires increased moisture in the blast for best results. The use of moisture with oxygen led to the use of higher blast temperature for further boosting iron production. Weirton has used up to 28 gr of moisture per cu ft of blast, four 4 per cent enrichment by oxygen and 1650 F blast temperature, and with improved burden as well, has produced more than 2000 tons of iron per day from one 25 ft-6 in. furnace—about 3.9 tons of iron per sq ft of hearth per day.

STEELMAKING

A 1300-ton mixer located near one end of the open hearth shop receives hot metal from the blast furnaces. It is heated by coke oven gas. Iron ladles are raised by crane and emptied into the mixer. Iron is poured out of the mixer into ladles, weighed and moved by electric locomotive to the open hearth or to bessemer converters located in the mixer building.

The three converters, each rated at 40 tons, are used only to blow metal for open hearth charge. A standard charge for these units consists of 60,000 lb of hot metal and 10,000 lb of scrap. The partial blow takes about 11 minutes and produces a metal containing about 2.5 per cent carbon, 0.12 per cent manganese and 0.006 silicon. Blowing pressures range from 15 to

Weirton has just completed a new sintering unit. Machine is 12 ft wide, considerably wider than generally used in the steel industry.

TABLE VI
Open Hearth Proportions

Size, tons	Hearth area, sq ft	Length, ft-in.			Area at center line of furnace, sq ft	Area of throat, sq ft	Area at uptake bridge-wall, sq ft	Uptake area, one end, sq ft	Area at regen-erator bridge wall, sq ft	Checkerwork heating surface, one end, sq ft
		Over-all inside buckstays	Knuckle to knuckle	Knuckle to furnace end						
275	690 817	74-11 to 75-5	40-8 to 42-6	16-0 to 16-5½	163 171	107.9	108.6	57 to 60	72.4	27,688
450	792 888	71-2 to 75-11	21-8 to 27-6	22-4 to 26-0	197 200	130 145	118 to 124	66 to 70	55 to 64	37,500 to 39,850
500	975	88-3	27-2	29-5	201.5	119	108	75.8	74	44,700
550	1221	94-0	25-1½	32-11¼	227.5	126	114	99.	75	24,921
600	1296	108-0	48-11¼	29-9⅜	239	70.5	76.9	97.75	128	40,250

25 psi, blast coming from a 75,000 cfm, 30-psi turbo-blower exhausting into a common blast system. Steam is used in the blast as a coolant. At times, some oxygen has been added to the bessemer blast to enrich it slightly. Since the installation of the third converter, this is unnecessary. Blown metal production runs about 5200 tons per day. A spare vessel and an auxiliary stand permit relining without excessive interruption of production.

Basic open hearth steel is produced in 14 open hearth furnaces: five rated at 275 tons, with hearths 46 to 48 ft long x 14 ft-10 in. to 17 ft-7 in. wide; five rated at 450 tons, with hearths 47 ft-8 in. to 51 ft-2 in. long x 17 ft-6 in. to 18 ft wide; one rated at 500 tons, with a hearth 59 x 17 ft-6 in.; two rated at 550 tons, with hearths 66 x 18 ft-6 in.; and one, said to be the largest in the world, rated at 600 tons, with a 75 x 18 ft-6 in. hearth. These dimensions give hearth areas ranging from 1.76 to 2.97 sq ft per ton of furnace capacity.

As might be expected, this development toward larger and larger furnaces, in which Weirton has pioneered, has resulted in considerable variation in furnace design and dimensions. Some principal characteristics are given in Table VI.

Three of the furnaces are equipped with two stacks and two fans each which alternately act as forced draft and induced draft units.

Furnace bottoms are 34 to 40 in. thick at the center of the furnace. They are built up of 1 or 2 in. of ganister, 6 to 12 in. of ladle quality firebrick, 13½ in. of chrome brick and a minimum of about 13 in. of rammed bottom mix. Backwalls are of basic brick 18 in. thick covered by the rammed bottom mix. Sloping backwalls are used. Basic brick is used for port end walls and down into the slag pockets. The three largest furnaces have single uptakes. All of the large furnaces have seven charging doors, ranging from 4 ft-4 in. square to 5 ft-2 in. x 6 ft.

Silica roofs are sprung arches 15 in. thick with 18-in. ribs every fifth course. Basic roofs are 12 in. thick with 12-in. ribs.

Checker work on each end of the furnace runs about 8200 cu ft on the smaller furnaces and 11,800 cu ft on the large furnaces. Checkerwork heating surface runs 45.3 to 100.7 sq ft per ton of furnace capacity. Two inches of insulation are applied to the side walls of the checker chambers.

Normally fuel oil is used on ten furnaces and pitch on four. Oil is received principally by barge, unloaded at the river dock, pumped to a 300,000-gal holding tank and repumped to the open hearth storage tanks. Six tanks provide a total storage capacity of 4,900,000 gal. Pitch is trucked in from a tar processing plant and dumped into a 100,000-gal storage tank.

Oil and pitch are pumped at 275 psi through recirculating systems in the open hearth. Oil is held at about 230 F, pitch at 300 F.

All of the furnaces are equipped with automatic controls on fuel input, air flow and furnace pressure. In addition, three furnaces have automatic combustion control and reversal equipment which will act, as desired, on time, temperature or temperature difference. Furnace pressure usually ranges 0.06 to 0.09 in. water column. Fuel consumption averages 3,150,000 Btu per net ton of ingots.

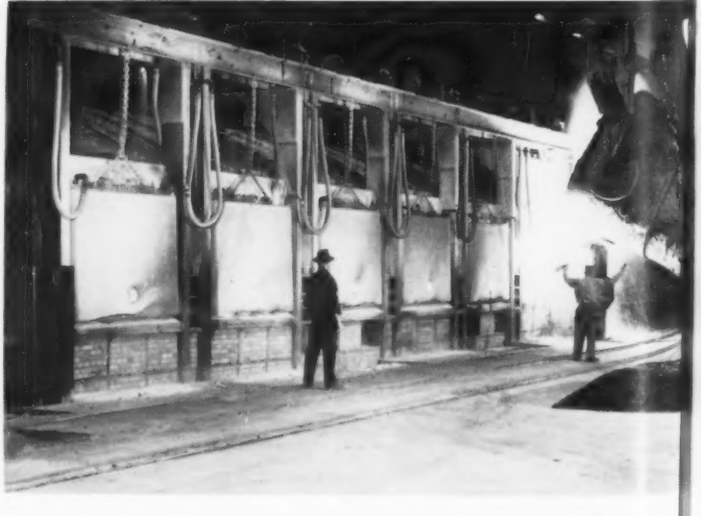
Eleven furnaces are equipped with waste heat boilers operating at 225-psi pressure, 500 F total temperature. These vary in rating from 600 to 1750 hp. Five are fire-tube units, six water-tube. They generate steam to show a coal equivalent of 275 tons of coal per day.

The small furnaces are usually charged with 65 per cent hot metal and 35 per cent scrap. Blown metal from the converters is used in the large furnaces to the extent of 70 per cent of the charge. On all furnaces, time of heat runs 13.5 to 15 hr, tap-to-tap. This gives individual furnace productions ranging from about 20.7 tons per hr on the small furnaces up to 46.5 tons per hr on the largest, all on gross time. Under comparable conditions, the use of blown metal charges reduces the time of heat by about 30 per cent.

The over-all furnace charge for the entire shop averages about 10.5 per cent hot metal, 63.1 per cent blown metal, 3.4 per cent cold iron and 23.0 per cent scrap.

Oxygen lancing of the bath for carbon removal is

Weirton operates 14 open hearth furnaces ranging in size from 275 tons to 600 tons. On the large furnaces, blown metal from converters forms about 70 per cent of the charge.



practiced on all furnaces. At present, four furnaces are equipped with oxygen lances through the furnace roofs. Two of these furnaces have basic roofs, two have silica roofs. On the remaining furnaces, lancing is done through the doors.

Flux consumption in the open hearth consists of 136 lb of limestone, 62 lb of raw dolomite 20 lb of burnt dolomite and two lb of fluorspar per ton of ingots. About 11 lb of ferromanganese and one lb of deoxidizers are used per ton.

Steel is produced in rimming and killed grades, with carbons generally of the order of 0.08 to 0.10 per cent. It is tapped into ladles ranging 275 to 290 tons capacity. The 275-ton furnaces tap into a single ladle. All others tap through a bifurcated spout into two ladles.

Steel is poured into ingots of various sizes, according to the type and end use. Open top molds range 22 to 27 in. in thickness, 38 to 53 in. in width, 69 to 95 in. in length and 14,950 to 26,663 lb in weight. Bottle top molds range 24 to 26 in. thick, 28 to 53 in. wide, 75 to 94 in. long and 13,400 to 26,000 lb weight. Hot top molds run 22 to 25 in. x 40 to 51 in. x 69 to 74 in. and 16,480 to 22,200 lb in weight.

Before pouring, ingot molds are checked for physical damage and for freedom from slag, scrap and dirt. Stools are blown with air to remove dirt. A slurry of lime is applied to the tops of the molds to prevent steel sticking to the mold. No dip or spray is used for the inside of molds. The cooling period is watched in an effort to have the mold about 400 F when pouring. Elapsed time between pouring and stripping ranges from 30 to 90 min, depending on type of steel and size of ingot.

The open hearth shop consists of four bays, side by side. The charging bay is 85 ft wide x 1338 ft long, and is served by two 100/25-ton cranes, one 100/25/10-ton crane and five charging machines of 7½ and 10-ton capacities. A leanto 45 ft wide runs along the back of the charging floor. The pouring bay, 60 ft wide x 1646 ft long, contains five 275/60/20-ton ladle cranes, one 175/40/15-ton crane and one 100/25-ton crane. Adjacent to the pouring bay is the mold yard, 103 ft wide x 1620 ft long, with three 15-ton cranes.

Paralleling this group of buildings is a stockhouse 103 ft wide x 804 ft long, served by five overhead cranes ranging 10 to 20 tons in capacity. The width of this building is divided into two levels, the higher being on the same level as the charging floor. Scrap is stored on the lower level, while charging boxes to be filled run in on tracks on the upper level. Limestone, dolomite, iron ore, etc., are stocked in bins in this building. Another scrap yard, 100 x 980 ft, provides additional storage.

A stripper building at the end of the mold yard is 88 x 185 ft and contains two strippers, one rated at 300 tons, one at 150 tons.

The mixer building, which also contains the converters, is 85 x 210 ft and is served by two cranes, one 150/30-ton, one 100/25-ton.

BLOOMING MILL

From the stripper building, the drag of ingot buggies is moved to the soaking pits. There are 14 rows of pits, nine containing four holes each, five containing three holes each. Of the latter, four are one-way, top-fired recuperative units, each hole being 24 ft long x 9 ft-6 in.

Large open hearth heats are tapped through bifurcated spouts into two ladles. The large furnaces produce up to 46.5 tons per gross furnace hour.

wide x 10 ft deep. The other pits are reversing regenerative units 18 ft long x 6 ft-3 in. wide x 8 ft-8½ in. deep. The 51 holes provide a total hearth area of 7116 sq ft.

All of the pits are fired with a mixture of blast furnace gas and coke oven gas in proportions of about 85:15, giving a heating value of about 165 Btu per cu ft. These gases are mixed in a nearby station which is arranged so that natural gas may be substituted in the mixture in the event of a shortage of coke oven gas.

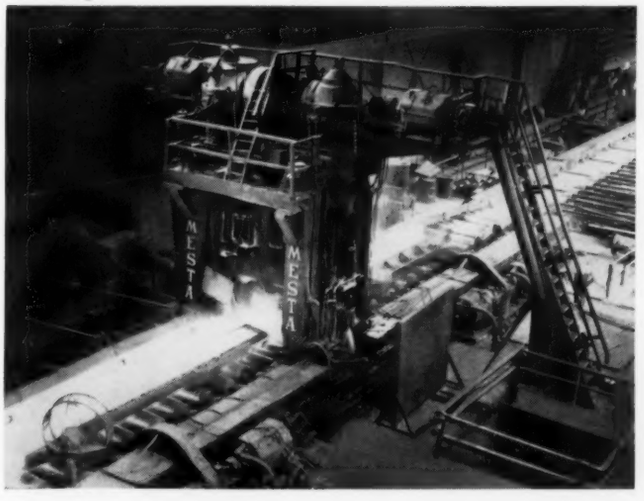
Each recuperative pit is equipped with automatic controls on temperature, fuel-air ratio and furnace pressure. Combustion air is preheated to 1000 to 1150 F.

Almost all of the ingots are charged to the pits at temperatures of 1100 to 1300 F. Heating time ranges 3 to 4½ hr. Fuel consumption averages 850,000 Btu per ton of ingots.

Ingots are charged into and drawn from the pits by three pit cranes, one rated at 7½ tons, two rated at 15 tons. An ingot buggy conveys the heated ingots from the pits to the blooming mill approach table.

The blooming mill is a 40-in. two-high reversing unit, driven through 18-in. spindles by a 25,000-hp, 42 in. and 66 in. x 60-in. twin-tandem cross-compound

This 40-in. blooming mill, driven by a 25,000-hp steam engine, has, at various times, set monthly records for the industry.



An automatic scarfing machine skins all four sides of the blooming mill product, using 100 to 150 cu ft of oxygen per ton of steel desurfaced.

steam engine. The engine operates on 225-psi steam and exhausts into a barometric condenser at about 27-in. mercury vacuum. A maximum speed of 125 rpm is attained.

Mill pinions are of herringbone design, 40-in. pitch diam, 7.855-in. circular pitch, with 50-in. face. The engine and pinions are located in an engine room 54 ft wide adjacent to the mill building.

Each mill housing post is 472 sq in. in cross section. Rolls are 37 in. in diam and have a body length of 92 in., carrying grooves of 8 and 13 in., and a 50-in. bullhead. Roll necks run in bronze and babbit bearings which are lubricated from a central automatic grease system. The top roll is balanced hydraulically by a pressure of 600 psi, and is raised and lowered at speeds up to 22 fpm by 12-in. screws of 2-in. pitch, driven by two 100-hp mill-type motors under magnetic control. A maximum roll lift of 49 in. is available.

While ingots are being rolled, they are manipulated by hydraulically operated side guards and fingers. Front and back mill tables attain speeds of 590 fpm.

Mill scale is washed into a scale pit and removed from there by grab bucket on an overhead crane.

In addition to the previously mentioned grease system serving the blooming mill roll neck bearings, there is an automatic grease system which lubricates the screwdown mechanism, another serving the table roll bearings, and a third serving the scarfing machine. A circulating oil system of 1500-gal storage capacity, 45-gpm circulation, takes care of the pinion stands.

Power for mill tables and auxiliaries comes from two 1500-kw motor-generator sets.

The 40-in. mill receives ingots of various sizes up to 24 x 53 in., 23,800 lb and, in 15 to 23 passes, reduces them to blooms ranging from 8 x 8 in. to 20 x 12 in. or slabs 25 to 49 in. in width and 4½ to 9 in. thick. About 80 per cent of blooming mill product is in the form of slabs, 20 per cent in blooms. Production averages 325 tons per hr, but the mill has set records of 4211 tons per 8-hr turn, 10,300 tons per day and 237,400 tons per month.

About 75 ft beyond the 40-in. mill is the automatic scarfing machine, which skins all four sides of the mill product. This machine uses 100 to 150 cu ft of oxygen per ton of slabs desurfaced.

Also in direct line with the 40-in. mill are a 300-ton crop shear, a six-stand 21-in. billet mill and a six-stand 18-in. bar mill which are not used at present and have been partially dismantled. All blooming mill product is at present moved from the mill line over a 110-ft transfer to a parallel table line 34 ft to one side. This line contains an 800-ton steam-hydraulic shear capable of cutting widths up to 49½ in. wide. Crop ends fall beneath the shear and are carried by inclined conveyor from the shear pit to a scrap box. Sheared product passes over two transfers into an adjacent storage yard.

STRUCTURAL MILL

The structural mill may operate on hot ingots directly from the soaking pits or on blooms. Cold blooms are moved by crane from the storage yard to the structural mill furnace. Hot blooms may be moved by a transfer car with a roller table top, which delivers directly to the structural mill furnace. Ingots are brought to the mill table by ingot car.

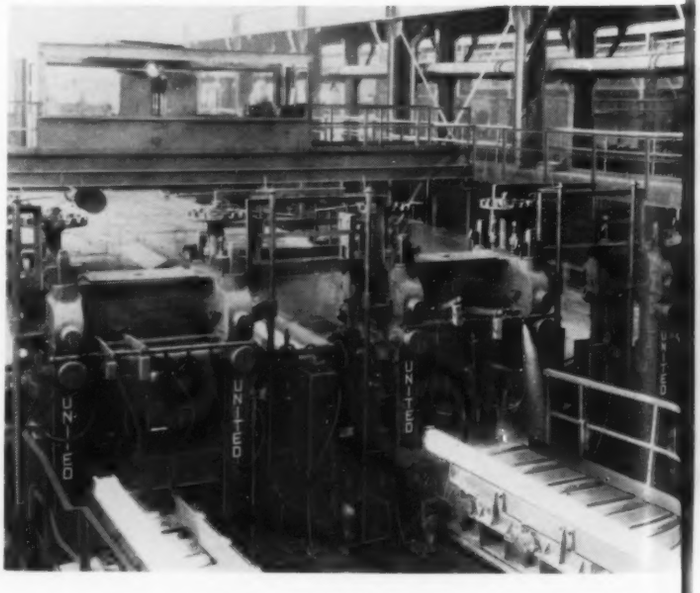
The furnace is a continuous recuperative unit, 18 ft-6 in. wide x 60 ft long, and rated at 60 tons per hr. It is heated with fuel oil or coke oven gas, with combination burners arranged in three firing zones. Complete automatic combustion control equipment is provided.

Blooms are moved through the furnace over water-cooled skids and a refractory soaking hearth by the action of a double pusher.

Heated blooms leaving the furnace move over roller tables to a 35-in. breakdown mill, a two-high reversing stand. The rolls are 35 in. in diam and have an 82 in. body length. The top roll is moved by 12-in. screws of 2-in. pitch, driven by two 100-hp mill-type motors. A maximum roll life of 40½ in. is available.

The 35-in. stand is driven by a 4000-hp, 0/50/100-rpm, 750-volt d-c motor, which receives power from a three-unit motor-generator set consisting of two 1750-kw generators and a 4900-hp, 6600-volt motor.

The structural mill produces channels, I-beams, H-beams, piling, angles, car center sills, etc.



Mill pinions have a pitch diameter of 35 in., a circular pitch of 4.78 in. and a 48-in. face. Motor operated side-guards and manipulators handle the blooms as they are reduced in the breakdown mill.

About 140 ft beyond the 35-in. stand are three stands of rolls, side by side: a three-high 29- x 70-in. roughing stand, a three-high 29- x 70-in. intermediate stand, and a two-high 29- x 48-in. finishing stand. The first two stands are driven by a 3000-hp, 70–140-rpm, 650-volt d-c motor. The finishing stand is driven by a 2250-hp, 65–90-rpm, 600-volt, d-c motor. Power for both of these drives comes from a motor-generator set consisting of two 1100-kw, 650-volt generators, two 900-kw, 600-volt generators and a 4600-hp, 6600-volt motor. It is also possible to couple all three stands together, so that either motor can drive the entire train.

To roll the smaller products, 23-in. stands and pinions can be substituted for the 29-in. stands on the same shoe plates. Also, a universal stand can be put in place of the finishing stand when the nature of the product requires it.

In all of these stands, rolls run in composition bearings. Babbited bearings are used for the pinion stands. Finishing train rolls are adjusted by manually operated screws.

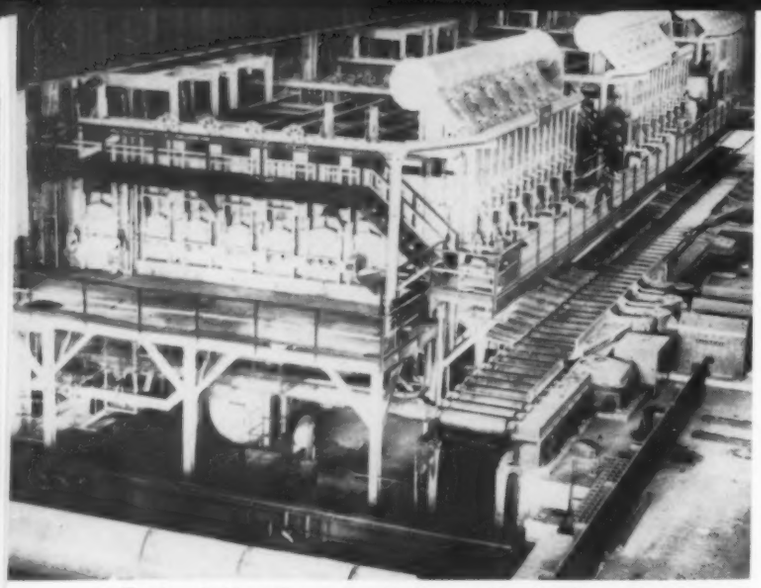
On each side of the finishing train are two traveling tilting tables which manipulate the steel through the various stands.

The structural mill receives blooms 202 in. long varying from 8 x 7 in. to 16 x 13 in. in section. It produces a full range of heavy structural shapes including 6- to 18-in. I-beams, 6- to 18-in. channels, angles from 4 x 4 in. to 8 x 8 in., H-beams from 6 x 6 in. to 14 x 8 in., as well as sheet piling, piling beams, car centers sills, shipbuilding channels, etc.

Rolling rates vary widely, depending on the prod-

TABLE VII
Strip Mill Data

Stand	Roll diam, in.		Roll body length, in.	Distance from preceding stand, ft-in.	Motor data				Gear ratio	Roll, rpm	Roll face speed, fpm
	Work roll	Backup roll			Hp	Voltage	Type	Rpm			
Hot mill											
Vertical edger	42	...	12	...	1500	6600	Induction	196	9.6	20.4	225
No. 1 rougher	44	...	54	34-9	4000	6600	Synchronous	450	23.3	19.3	222
No. 2 rougher	44	...	54	48-10	4000	6600	Synchronous	450	17.24	26.1	300
No. 3 rougher	44	...	54	72-8	6000	6600	Synchronous	450	11.5	39.1	450
No. 4 rougher	35	49	54	100-3	6000	6600	Synchronous	450	8.33	54.0	495
No. 5 rougher	35	49	54	154-3	6000	6600	Synchronous	450	7.08	63.5	580
Finishing scale-breaker	23¼	...	66	298-7	500	600	d-c	160/525	7.96	20.1/65.9	123/403
No. 6 finisher	26¼	49	54	15-10	(2) 2000	600	d-c	200/400	5.241	38.2/76.4	260/520
No. 7 finisher	26¼	49	54	18-0	(2) 2500	600	d-c	200/400	3.4	59/118	400/800
No. 8 finisher	26¼	49	54	18-0	(1) 2000	600	d-c	175/350	2.0	87.5/175	600/1200
					(1) 3500	600	d-c	175/350			
No. 9 finisher	26¼	49	54	18-0	(1) 2000	600	d-c	175/350	1.486	117/234	800/1600
					(1) 3500	600	d-c	175/350			
No. 10 finisher	26¼	49	54	18-0	(1) 2000	600	d-c	175/350	1.19	147/294	1000/2000
					(1) 3500	600	d-c	175/350			
No. 11 finisher	26¼	49	54	18-0	(1) 2000	600	d-c	175/350	1.0	175/350	1200/2400
					(1) 3500	600	d-c	175/350			
Cold mills											
No. 1 Tandem											
No. 1 stand	16	37	52	...	500	600	d-c	400/800	14.09	28.4/56.8	119/238
No. 2 stand	16	37	52	25-0	500	600	d-c	400/800	11.35	35.2/70.4	148/296
No. 3 stand	16	37	52	25-0	500	600	d-c	400/800	9.1	44/88	184/368
No. 4 stand	16	37	52	13-6	500	600	d-c	400/800	7.14	56/112	234/468
No. 4 Tandem											
No. 1 stand	19	48¾	35	...	700	750	d-c	350/875	7.13	49.1/123	244/610
No. 2 stand	19	48¾	35	12-7	1750	750	d-c	300/600	2.82	106.5/213	528/1056
No. 3 stand	19	48¾	35	11-9	1750	750	d-c	175/350	1.0	175/350	868/1735
No. 4 stand	19	48¾	35	11-9	2500	750	d-c	250/500	1.0	250/500	1240/2480
No. 5 Tandem											
No. 1 stand	19	48¾	35	...	1000	600	d-c	110/275	1.0	110/275	545/1362
No. 2 stand	19	48¾	35	12-7	2500	600	d-c	150/350	1.0	150/350	744/1736
No. 3 stand	19	48¾	35	11-9	3000	600	d-c	250/500	1.0	250/500	1240/2480
No. 4 stand	19	48¾	35	11-9	3000	550	d-c	312/625	1.0	312/625	1550/3100
No. 6 Tandem											
No. 1 stand	21	53	42	...	1750	750	d-c	70/210	1.0	70/210	385/1155
No. 2 stand	21	53	42	13-0	3500	750	d-c	125/312.5	1.0	125/312.5	687/1718
No. 3 stand	21	53	42	13-0	3500	750	d-c	225/450	1.0	225/450	1237/2474
No. 4 stand	21	53	42	13-0	(2) 1750	750	d-c	225/450	0.645	348/697	1924/3847
No. 5 stand	21	53	42	13-0	(2) 2250	750	d-c	250/450	0.5	500/900	2749/4948
No. 7 Tandem											
No. 1 stand	23	56	52	...	3000	750	d-c	110/315	1.0	110/315	662/1897
No. 2 stand	23	56	52	14-0	5000	750	d-c	175/410	1.0	175/410	1054/2469
No. 3 stand	23	56	52	14-0	(2) 2500	750	d-c	175/410	0.71	247/578	1487/3480
No. 4 stand	23	56	52	14-0	(2) 3000	750	d-c	300/600	0.71	423/846	2547/5094
No. 5 stand	23	56	52	14-0	(2) 3500	750	d-c	415/800	0.71	585/1128	3522/7394
No. 7 skin pass	20½	46¾	54	...	500		d-c	500/1000	5.36	93.5/187	500/1000
No. 8 skin pass	21½	49	54	...	(2) 750	600	d-c	850/1200	1.65	515/727	2900/4100



Each of the three continuous slab-heating furnaces is rated at 200 tons per hr. They have hearths 93 ft long x 28 ft wide.

uct, but average about 50 tons per hr. Actually, production of this mill is limited somewhat by heating capacity of the furnace and by the finishing facilities.

Product leaving the hot mill is carried over a runout table to a hot saw and gage, where it is cut to the desired length. These pieces then proceed to a three-section stationary rail-type cooling table 70 ft long and totaling 225 ft in width. At the other side of this transfer, another table conveys the sections to either of two straightening machines. One of these is a 32-in. eight-roll machine, the other a 45-in. four-roll machine. These machines may be moved into and out of the table line by hydraulic mechanism, so that either unit may be used as desired.

Following the straighteners, the two table lines are again connected by a transfer about 75 ft wide. Sections may be taken over this transfer and out the original mill line or they may be taken off on a third table line between the other two and moved to a combination shear and punch, and on to a cradle.

Still another transfer connects the mill line to a layout of parallel tables and transfers containing a cold saw and a gag press straightener. At the end of these tables are two combination shear and punch machines, and an inspection table.

STRIP MILL

A pioneer in the strip field, Weirton began with two narrow mills (a 10-in. mill and a 16-in. mill, neither now in use) and in 1927 installed a strip mill designed to roll 48-in. strip. This mill, now designated a 54-in. unit, was rebuilt in 1947 and again in 1955 to increase its productive capacity. The 1947 rebuild included an increase in width to 66-in. Because of the press of postwar business, only the finishing train was rebuilt at that time.

The 1955 project was pointed toward increasing production by the use of heavier slabs and higher rolling speeds, requiring more drive power. Basically, this rebuild used the revamped finishing train (changing it from 66 to 54 in. with an additional drive motor added to each stand) and included a complete rebuild of the roughing section, extending it back beyond the entry of the original roughing train. At the same time, coilers were moved in the opposite direction to give a longer runout table. The entire project is an example of good engineering and ingenuity.

As now constituted, the mill consists of a separate vertical edger, three 2-high roughers, two 4-high roughers, a 2-high scalebreaker and six 4-high finishers (see Table VII). It receives slabs ranging 24 to 49 in. in width, 4½ to 9 in. in thickness, and 12 ft-8 in. to 26 ft in length. Slab weight ranges between 9350 and 23,955 lb, with 20,000 lb a good average. The mill turns out strip 24 to 49 in. wide down to No. 14 gage, up to 45 in. to No. 16 gage and up to 39 in. to No. 18 gage. It has set records of 580 tons per hr, 3583 tons per 8-hr turn and 9441 tons per day. It is officially rated at 3,000,000 tons per year.

Slabs are moved by overhead crane to a magazine feeder, from which they are moved over the furnace charging table, 181 ft long, across the back ends of the furnaces. A double pusher on each furnace moves slabs from the charging table into and through the furnace.

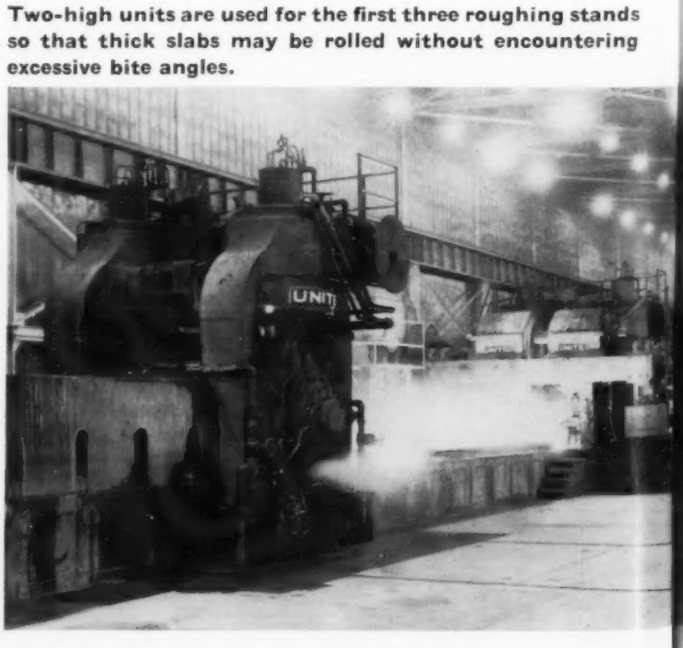
Each of the three continuous slab heating furnaces is rated at 200 tons per hr. They are of recuperative, triple-fired design, 118 ft-7 in. over-all length. They have hearths 93 ft long x 28 ft wide. Of the total hearth length, 23 ft-8 in. is devoted to the soaking zone. The steel-cased furnaces have flat suspended roofs of semi-silica brick, with one in. of insulation. Sidewalls carry 4 in. of insulation, and 10½ in. is used under the hearth.

The furnaces are designed to burn coke oven gas, natural gas and fuel oil. Each of the three firing zones in each furnace has individual controls on fuel input, fuel-air ratio and temperature. Furnace pressure is also automatically controlled.

Air for combustion is supplied by a 190,000-cfm fan on each furnace. The air is pushed through a two-pass silicon carbide tubular recuperator, and is preheated to about 650 F. A 200-ft stack serves each furnace.

Closed circuit television cameras are located at the charging table and the top of the slope of each furnace, with a receiver on the furnace operating table. Another camera is placed on top of the last roughing stand,

Two-high units are used for the first three roughing stands so that thick slabs may be rolled without encountering excessive bite angles.



pointing toward the finishing train. This camera is connected to a receiver in the roughing pulpit and another in the furnace delivery table pulpit.

A cable-operated car is provided to carry slabs from the furnace discharge table back into the slab yard.

The heated slabs, at temperatures of 2250 to 2300 F, are expelled from the furnace by the action of the furnace pushers and slide down the discharge slopes to the mill table, where spring bumpers absorb the impact. Passing over the furnace and approach tables, the slabs continue on through the mill stands, details of which are given in Table VII.

No. 2, 3 and 5 roughers are equipped with integral vertical edging rolls located just ahead of the horizontal rolls. On No. 2 and 3 stands, the edgers are driven by a 500-hp motor, on No. 5 stand by a 200-hp motor, all of 600 volts d-c. Speeds of the edger motors are controlled to synchronize vertical roll face speeds with that of their respective horizontal rolls.

The roughing mill drives are arranged to provide inching control to aid in changing rolls.

Two-high stands were used for the first three roughers in order to take advantage of the smaller roll bite angle offered by large diameter rolls, making it possible to enter thicker slabs.

Hot mill roll diameters are such that backup rolls from the four-high stands, when used down to 44 in. in diam, can be used in the three two-high roughers. When they have thus been used down to about 33 in. in diam, they can be machined for use as arbors for sleeved rolls to be used again as backup rolls.

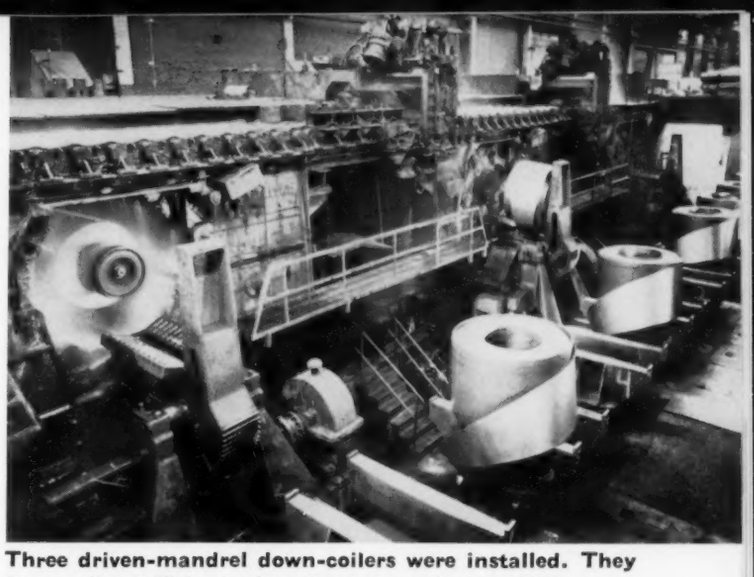
The table following the roughing train is about 288 ft long and is driven through line shafts by 50-hp mill-type motors.

An upcut crop shear is located ten ft ahead of the finishing scalebreaker. It is driven by a 100-hp d-c motor.

Between the finishing stands are loopers to take up slack in the strip between successive stands. Each looper is operated by a d-c motor which develops 140 ft-lb stall torque. A 30-kw, 55-volt generator serves the loopers.

Mill screws on each of the first three roughers are driven by one 50-hp mill motor, with two 100-hp motors on the fourth and fifth stands. In the finishing train, screwdowns are driven by one 12-hp motor on the scalebreaker, two 100-hp motors on No. 6 and 7 stands, two 50-hp motors on No. 8, 9 and 10, and two 30-hp motors on No. 11. Where two motors are used, a magnetic clutch permits their operation individually or in unison.

The finishing stands, now 26¼ in. and 49 in. x 54 in., were narrowed from 66 in. in the 1955 rebuild, but were left on their original locations.



Three driven-mandrel down-coilers were installed. They form coils of 28-in. inside diameter and up to 76-in. outside diameter.

The main drive setup on the finishing train is rather unique. The first two finishers are driven by the same motors which had been in use previously. In order to step up power on the last four stands, the existing 3500-hp motors were fitted with new armature shafts able to transmit 5500-hp. To each of these motors, which remained on their original foundations, a 2000-hp unit was coupled in tandem.

Power is supplied to these motors by a combination of motor-generator sets and mercury arc rectifiers. There are three motor-generator sets, each consisting of two 1500-kw, 600-volt generators driven by a 4200-hp, 6600-volt synchronous motor. Previously, these sets were paralleled with two 3500-kw, 600-volt rectifiers to feed a common bus system serving the finishers. In the new arrangement, each mill stand is individually fed by one of the 1500-kw generators paralleled with a rectifier. On the first two stands, the rectifiers are 2500-kw, while a 3500-kw rectifier is used for each of the last four stands.

The mill is started by voltage control of the generators with the rectifiers in parallel. Load balance regulators divide the load properly between the motors and between the generators and rectifiers.

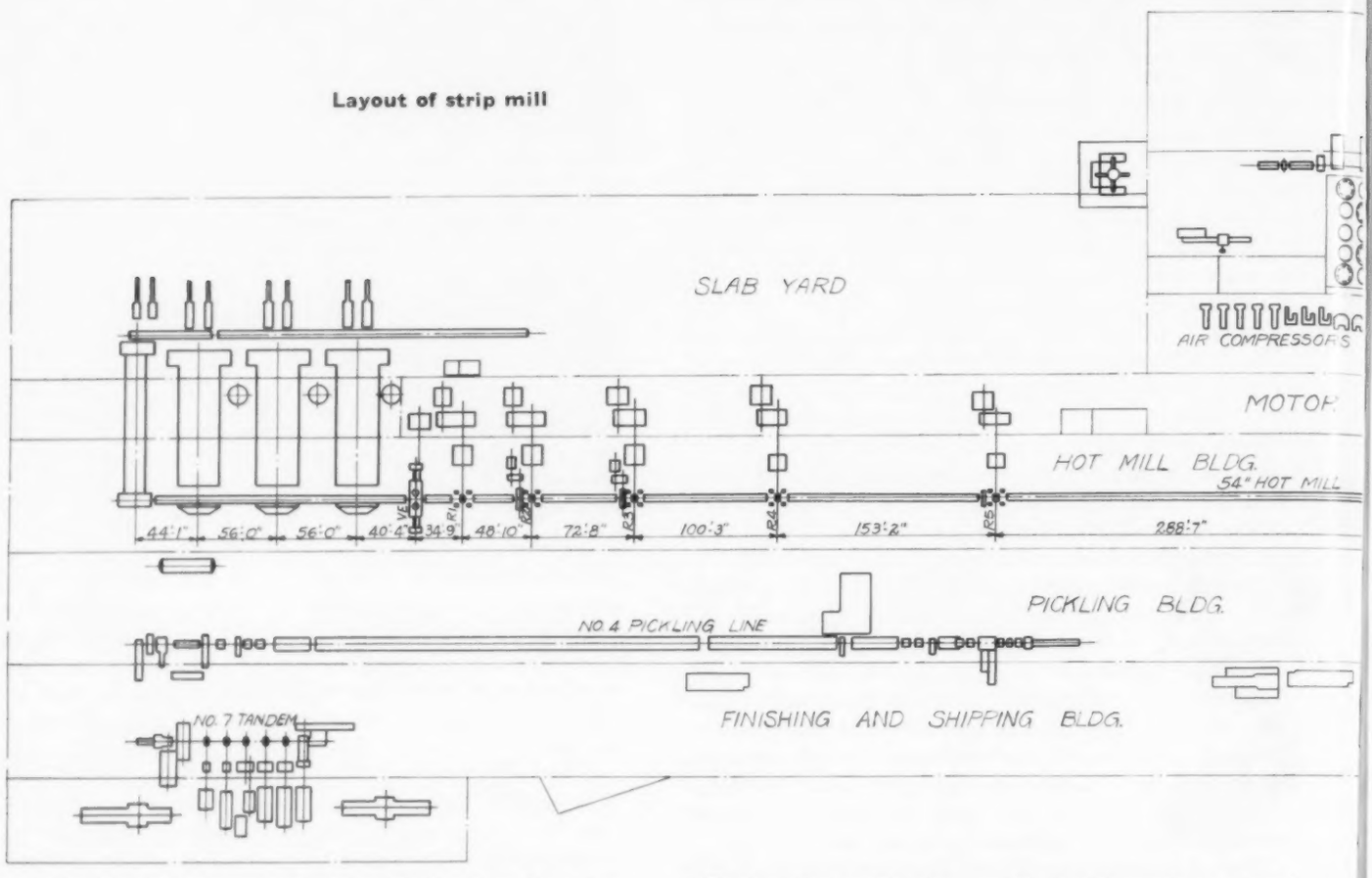
The control system uses static voltage regulators incorporating IR compensation and provisions for jogging. Current regulators for motor field current provide fine speed adjustment with rapid response.

The motor-generator sets, rectifiers, mill drive motors, exciters, regulators, control boards and switchgear are located in a motor-room located alongside the mill. Here also are the motor-generator sets for the various auxiliaries. Rotating equipment is cooled by air.

The hot mill uses 77.8 kwhr per ton of strip product.

On 2-high stands, oil-film bearings are applied to the roll necks. On 4-high stands, work rolls run in roller bearings, backup rolls in oil-film bearings. The bearings for all backup rolls are duplicates. Babbitt bearings are

Layout of strip mill



used in the initial vertical edger. Roller bearings are used on all table rollers.

As the steel passes through the mill, scale is removed by hydraulic sprays at both sides of No. 1 rougher and the finishing scalebreaker. Water at 1200-psi pressure is supplied by two 1400-gpm centrifugal pumps. Scale falls through the mill table and is hydraulically flushed to a scale pit.

TABLE VIII
Strip Mill Buildings

Building	Length, ft	Width, ft-in.	Cranes		
			Number	Capacity, tons	Span, ft-in.
Slab yard	800	128-0	3	(1) 15	120-0
				(2) 60	120-0
Hot mill	1925	80-0	3	(1) 60/25	76-2
				(1) 30/10	76-2
				(1) 10	76-2
Hot mill motor room	975	43-2	2	(1) 50/10	37-11
				(1) 15	37-11
Pickling	1925	80-0	3	(1) 20	76-2
				(2) 40	76-2
Cold mill	1125	100-0	3	(1) 25/10	96-2
				(2) 10	96-2
Anneal	725	74-0	4	(2) 40/10	70-0
				(2) 10	70-0
Circular anneal	400	100-0	1	30	93-8
Shipping	1125	100-0	4	(1) 15	96-6
				(3) 10	96-6
Finishing and shipping	1925	80-0	5	(1) 15	76-2
				(1) 20	76-2
				(1) 40/20	76-2
				(2) 50/15	76-2
Cold mill motor room	325	60-0	1	50	54-0
Cold mill roll shop gantry	...	...	1	10	35-0
Hot mill gantry	...	...	1	15	28-7½
Scale dipping	...	...	1	15	110-0

Each mill stand is also provided with service water at 30, 80, and 125-psi pressure. The roughing stands and the first three finishers also have 250-psi water. Operators can select the water pressure required on each stand.

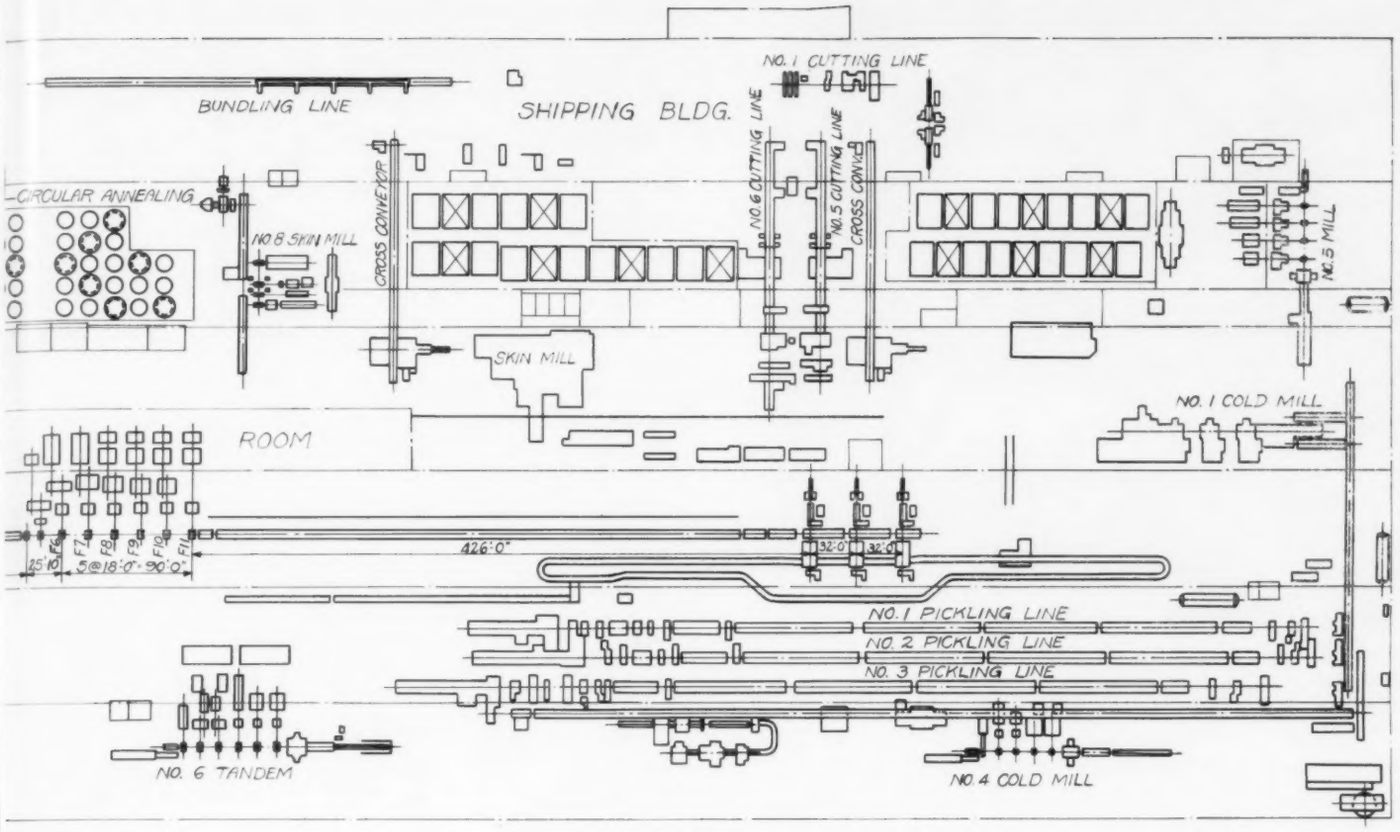
Leaving the finishing train, strip passes over a runout table about 426 ft long. Rollers in this table are individually driven by 3-hp, 300-volt, 800-rpm d-c motors under adjustable voltage control. Four 360-kw, 300-volt, 1200-rpm generators provide power for the table motors.

At the end of the runout table are three down-coilers, with each mandrel driven by a 350-hp d-c motor. These motors draw power from three 360-kw, 360-volt d-c generators. Coils of 28-in. I.D. and up to 76-in. O.D. are formed.

Coils are removed from the coilers by a traveling downtilter and deposited on a previously existing (but modified) car-type cooling conveyor. This unit travels in a long loop under the mill floor. It consists of 115 cars on 8-ft centers, traveling at 30 fpm. The 920-ft total length gives coils time to cool (about two hours) before they come to the unloading station. Here, coils are removed by another upender, placed in cradles on an inclined conveyer that carries them up to floor level, where they are taken to the pickling department.

STRIP PICKLING

Four continuous pickling lines located in a building paralleling and adjacent to the strip mill prepare the strip for subsequent processing. Two of these are 575 ft long, one 650 ft and one 675 ft. Each contains four acid tanks and one rinse tank, constructed of steel lined with rubber and acid-resistant brick. Acid tanks



are 7 ft-8½ in. wide and 5 ft-2 in. deep, inside the steel. In three lines, the tanks are 81 ft-4½ in. long and hold 12,340 gal of solution. The largest line has tanks 89 ft-2 in. long, which hold 13,610 gal. Speed range in the three shorter lines is 450 to 600 fpm; in the newest line, it is 450 to 750 fpm.

Pickling solutions contain 18 to 25 per cent sulphuric acid and are heated to 205 to 220 F by steam jets under automatic control.

All tanks have covers of rubber-lined steel, vented to collector fans.

The ends of successive coils may be butt-welded or stitched together.

Pickling department capacity is set at 231,000 tons per month.

From the exit ends of the picklers, coils are moved by conveyers to the various cold reduction mill areas.

COLD MILLS

Cold reduction facilities consist of five tandem cold mills which to some extent illustrate the development of these units. No. 1 mill is, by today's standards, slow and low powered. Each successive unit is faster and more heavily powered than the preceding installation with the most recent mill having a maximum delivery speed of 7394 fpm and drive power totaling 26,000 hp. Table VII gives characteristics of these mills. A sixth tandem will be in operation in 1959.

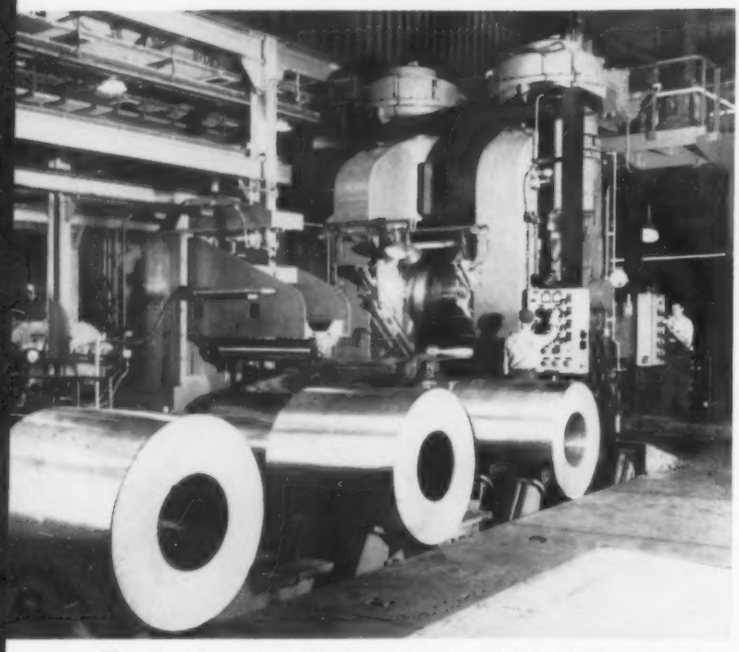
Except for No. 1 mill, which uses roller bearings on work rolls and backup rolls, these mills have roller bearings on work rolls and oil-film bearings on backup rolls.

The drive motors on No. 1 mill draw power from a common bus fed by a 1500-kw motor-generator set. No. 4 mill motors, also on a common bus, receive power from a motor-generator set made up of two 3000-kw, 750-volt generators and an 8400-hp, 6900-volt synchronous motor.

No. 5 mill motors are fed by individual generators. One 600-volt set, composed of a 480-kw, an 800-kw, a 2000-kw and a 2400-kw generator driven by an 8000-hp motor, feeds stands 1, 2, and 3 and the reel. Another set, of two 1450-kw, 500-volt generators and a 5100-hp motor, serves stand 4.

The motors on No. 6 mill operate on a common bus,

No. 7 cold reduction mill, a 23-in. & 56 in. x 52 in. unit, has the unusually high delivery speed of 7394 fpm. Its main drive motors total 26,000 hp.



No. 8 skin-pass mill in the strip steel department can process coils up to 30,000 lb in weight at speeds up to 4100 fpm.

fed by two motor-generator sets, each consisting of two 3500-kw, 750-volt generators driven by a 9900-hp synchronous motor.

No. 7 mill, with the unusually high delivery speed of 7394 fpm, is heavily powered, with each stand having individual 750-volt generators. The first stand is served by a 2400-kw generator, the second and third stands by two 2000-kw generators each, the fourth stand by two 2400-kw generators and the fifth by three 2000-kw generators. The reel draws from a 2000-kw generator. All of these generators are set up in two sets, each driven by a 15,000-hp, 6900-volt synchronous motor.

No. 1 tandem mill rolls sheet stock to gages of 0.029 to 0.125 in. up to 49 in. wide at rates averaging about 31 tons per hr. It has a monthly capacity of 22,000 tons.

No. 4 mill rolls tin plate to gages of 0.008 to 0.020 in. up to 33½ in. wide at rates of 37 tons per hr. It will turn out 30,000 tons per month.

No. 5 mill rolls both tin plate and sheet stock. Its product ranges 0.008 to 0.05 in gage and up to 33½ in. wide. The monthly capacity is 40,000 tons per month. Production rates go up to 40 tons per hr on tin plate and 56 tons per hr on light sheet.

No. 6 mill, with a monthly capacity of 50,000 tons per month, rolls tin plate in gages of 0.008 to 0.025 in. up to 38 in. wide at a rate of 64 tons per hr.

No. 7 mill rolls tin plate in gages of 0.0055 to 0.042 in. and widths up to 48 in. Rolling rates up to 75 tons per hr are attained. Monthly capacity is 55,000 tons.

The new No. 8 mill will roll sheet stock to gages of 0.015 to 0.135 in. up to 49 in. wide at rates averaging 62 tons per hr. It will have a monthly capacity of 45,000 tons.

Strip and sheet finishing equipment is located in four separate areas. In the strip mill unit, which is devoted principally to the finishing of sheet stock, there are 12 rectangular radiant tube annealing covers ranging 15½ to 22 ft in length and 6½ to 15½ ft in width. Each cover will take six or eight stacks of coils 48 to 60 in. in diam in piles 75 to 90 in. high. Three bases are provided for each cover.

There are also 12 cylindrical single stack annealing covers heated by radiant tubes for coil annealing. These units are 10 ft-2 in. I.D. and will take 72-in. coils piled to a height of 200 in. They also have three bases for each cover.

All of the annealing covers are fired with coke oven gas. Annealing temperatures are usually between 1130 and 1350 F.

Annealing capacity of this department is 33,500 tons per month.

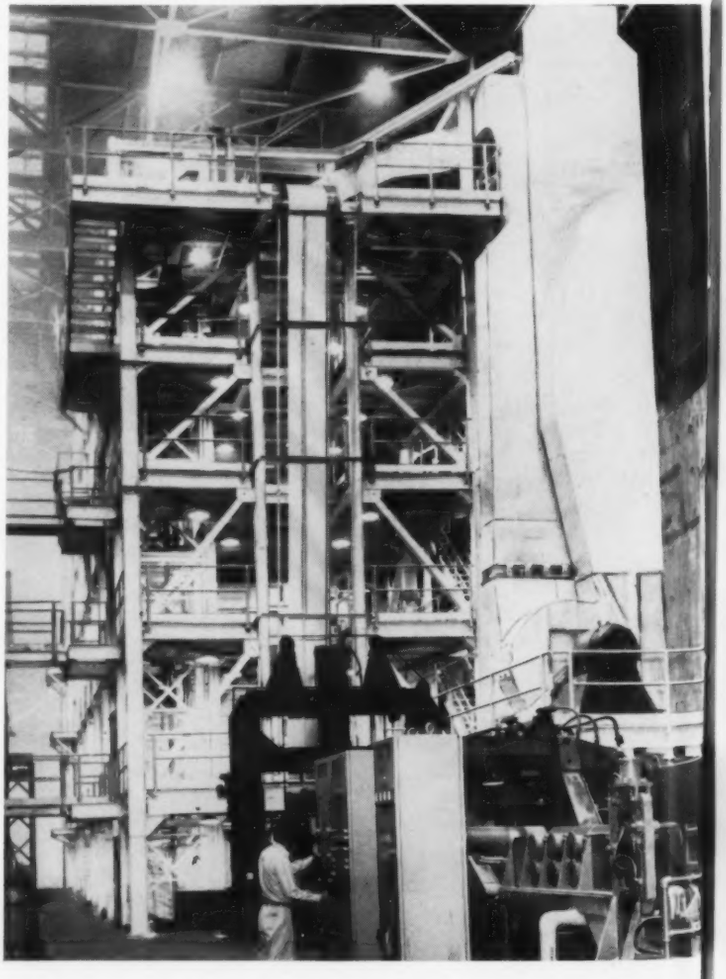
Furnace atmosphere for annealing is provided by three 25,000-cu ft per hr gas conditioning machines.

Temper mills in this department are two 54-in. four-high single stand units, details of which are given in Table VII. There is also a two-high 26 x 60 in. sheet mill and two two-high 20 x 48 in. skin pass mills.

Other equipment here includes a four-arm vertical plunger type batch pickler, a 48-in. combination unit for cutting, leveling and resquaring hot rolled sheets, two flying shear lines, two 48-in. slitters, four roller levelers, one stretcher leveler and two resquaring shears.

Three roll lathes (36, 40 and 50 in.), seven roll grinders (26, 28, 40, 50 and 60 in.) and a shot blast unit provide facilities for keeping hot and cold strip mill rolls in condition.

This view of the entry end of one of Weirton's four continuous galvanizing lines shows part of the cleaning section, followed by the annealing unit.



SHEET MILL

Another finishing center, devoted principally to galvanizing and terne coating, is located on the site of an old sheet mill from which the original equipment was removed. Here are ten radiant tube annealing covers, with 34 bases, for coils and sheet, all burning coke oven gas. One two-high 28-in. x 54-in. skin pass mill, capable of speeds up to 3200 fpm, is also installed here.

Galvanizing is now done principally in four continuous galvanizing lines which provide capacity for 35,000 tons per month.

One line is designed to process cold rolled strip in coil form, taking coils of 16½, 20 or 24 in. I.D., 84 in. maximum O.D. and 65,000 lb maximum weight. It will handle widths of 20 to 50 in., gages of No. 10 to No. 30. The other three lines process gages of No. 16 to No. 30.

The entry section of this line contains a combination resquaring shear and welder, as well as a side trimmer. Strip then passes through a cleaning section containing a scrubber, an electrolytic cleaning tank, another scrubber, a washer and a dryer. In the processing section, the strip goes through a preparation furnace, a galvanizing pot, a cooling tower, a water dip and a dryer. Following a chemical treatment tank and a dryer, the strip may be recoiled or it may be sheared into lengths.

On the exit end, coils may be formed up to 75 in. O.D. and 30,000 lb maximum weight. If the stock is sheared as it leaves the line, lengths may range from 48 to 192 in.

Line speed may range 30 to 300 fpm through the processing section and 30 to 400 fpm through entry and exit ends.

The other three lines are, in general, similar, except that one line does not have recoiling facilities and produces only cut lengths.

There are also a terne pot, an electrolytic cleaning line and a flying shear cutting line.

TIN MILL

The third center of finishing activity is the tin mill, which is located at the north end of the plant. Coils from the cold reduction mills at the strip mill are brought here in railroad cars to be finished into tin plate.

Three electrolytic cleaning lines (75,000 tons per month), 30 radiant tube type annealing covers (70 to 250 tons per charge, 80,000 tons per month), a continuous annealing line and four skin pass mills (104,000 tons per month) prepare the coils for coating. The continuous annealing line is a recent installation. It has a nominal capacity of 60 tons per hr on strip 0.01 in. thick, 30 in. wide. Coils 16½ in. I.D., 85 in. maximum O.D., up to 45 in. wide and up to 60,000 lb in weight may be handled. Gages may range from 0.0075 to 0.015 in.

The entry section of this line contains a caustic dip tank, a scrubber, an electrolytic cleaner, a second scrubber, a rinse tank and a dryer.

The middle or annealing section of the furnace runs at speeds up to 2000 fpm. Inverted looping towers before and after this section provide 700 ft storage. Nevertheless, it is usually necessary to slow down the annealing section to 500 fpm while welding the ends of successive coils together.

The entry section (which contains a cleaning unit) and the delivery section can run at speeds up to 2400 fpm in order to make up for delays in changing coils.

The annealing section is divided into four zones:

The heating zone, containing 12 vertical passes of the coil, is heated by gas-fired radiant tubes, arranged in six temperature control zones. With an annealing temperature of 1225 F, this zone is held at 1300 to 1500 F.

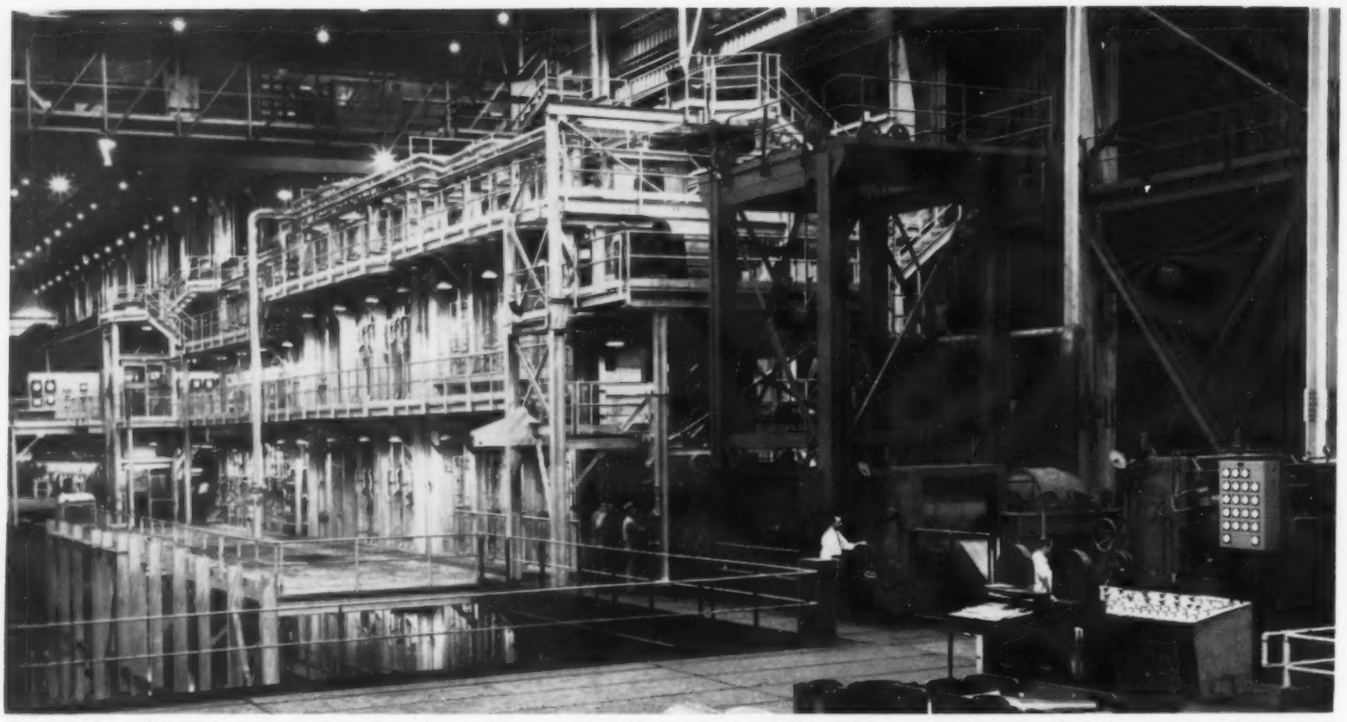
In the holding zone, the strip makes nine passes. Heat is supplied by electric resistance elements totaling 550 kw arranged in five separate zones.

The slow cooling zone contains 11 passes. It is equipped with four zones of air-cooled tubes and four zones (1000 kw total) of electric resistors for use in bringing the zone up to temperature when starting up. Strip is cooled from 1225 F to about 900 F in this zone.

The fast cooling zone contains 14 passes of strip. It is cooled by water-cooled tubes, bringing strip temperature down to about 450 F. Following this, the strip goes through a water quench and a dryer. Temperature recorders are installed at the exit of each zone of the annealing section. There are also recorders for oxygen, hydrogen, furnace pressure and atmosphere flow.

The length of strip in each zone and the time spent

This shearing line at the sheet mill cuts up galvanized coil stock into the desired lengths.



At the tin mill, this continuous cleaning and annealing line processes the cold reduced strip prior to temper rolling and tinning. It operates at speeds up to 2000 fpm.

in each zone at the maximum speed of 2000 fpm, is as follows:

	Ft of strip	*Time, sec*
Heating zone	768	23.2
Holding zone	598	17.9
Slow cool zone	730	22.0
Fast cool zone	1000	30.0

Furnace pressure is maintained at 0.2 to 0.5 in. water column by prepared gas containing four to six per cent hydrogen and the remainder nitrogen. Consumption of this atmosphere gas runs 26,000 to 34,000 cfhr.

The line uses about 1400 cu ft of coke oven gas, 9 kwhr of electric power and 800 gal of water per ton of strip annealed.

Monthly production from this unit is about 25,000 tons. A duplicate line will be installed in 1959.

The skin-pass mills are two-stand units, with a four-high stand followed by a two-high stand. Their characteristics are as follows:

Mill No.	*1*	*2*	*3*	*4*
Four-high, in.	8 & 38 x 42	8 & 38 x 42	9 & 38 x 45	10 or 20 & 38 x 52
Two-high, in.	26 x 42	26 x 42	26 x 45	29½ x 52
Fpm, max	2600	2600	5000	5200
Tons, per day	740	740	1000	1100

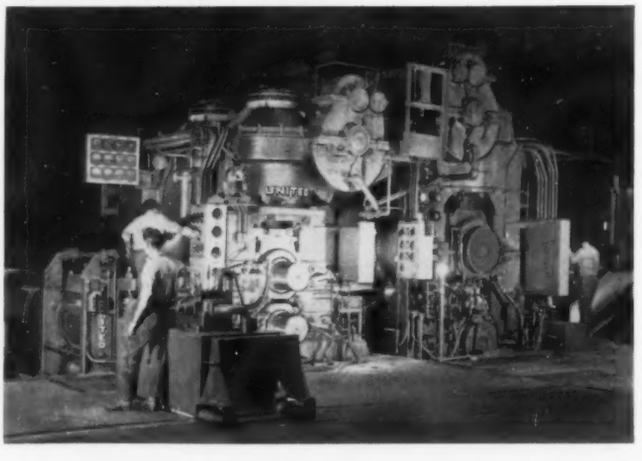
The combination of a four-high stand and a two-high stand in tandem is somewhat unusual, but the use of a four-high stand for the temper rolling, followed by a two-high stand for flattening, is thought to give a better product.

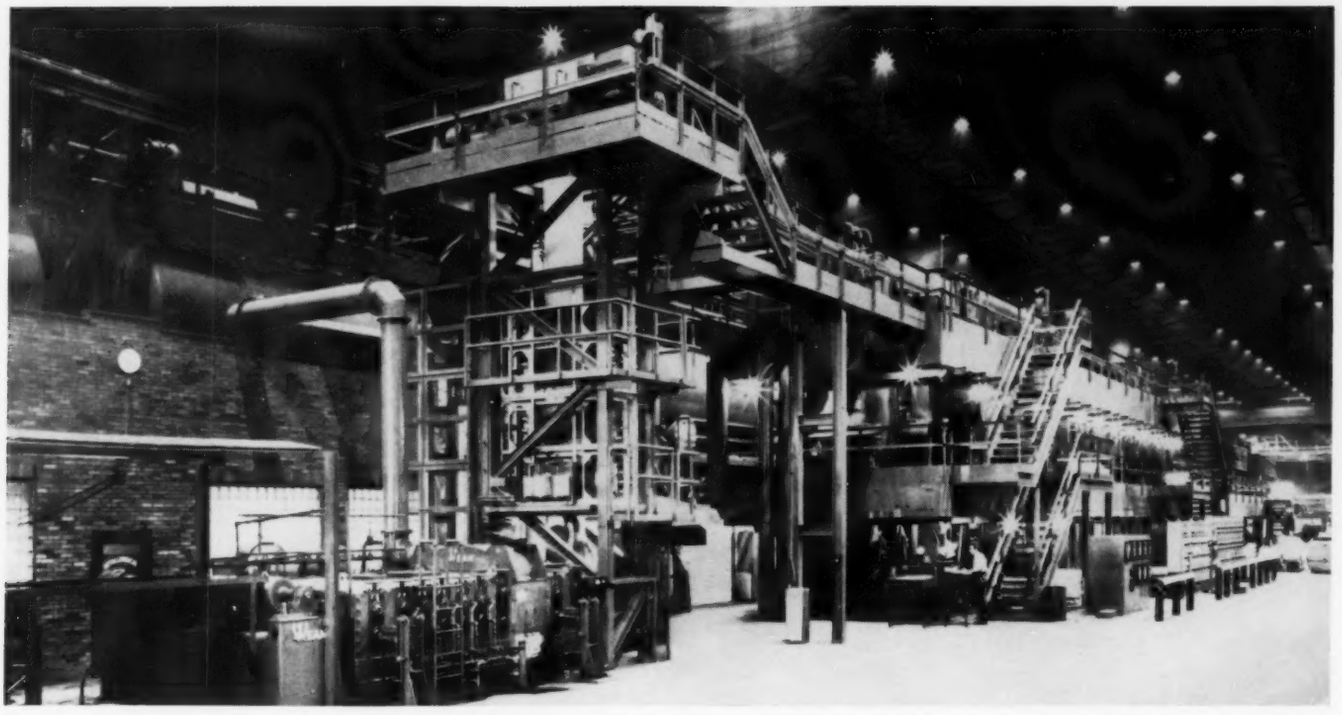
There are now five continuous electro-plating lines in the Weirton tin mill. One of these (No. 1) is used to apply a zinc coating to the strip. This line runs at about 350 fpm for a 0.1 oz per sq ft coating, 175 fpm for 0.175 oz per sq ft and 150 rpm for 0.2 oz per sq ft. Monthly production from this line approximates 9500 tons.

The other four coating lines are used to produce tin plate. These lines are roughly 550 ft over-all length and include uncoilers, pinch rolls, shear, seam welder, looping pit, tension unit, electrolytic cleaner, scrubber, pickling tank, scrubber, plating unit, induction reflow unit, quench tank, chemical treatment and washing unit, tension unit, electrostatic oiler, shear and recoiling reels.

The strip is coated one side at a time, the bottom being plated in the lowest of three decks. After the bottom is plated, the strip makes a 180-degree turn and reverses its direction of travel through the second deck, where the top of the strip is plated. At the end of the second deck, another 180-degree turn is made, returning to the original direction of travel through the third deck. In tanks on the third deck, dragout recovery is effected and the strip thoroughly washed, prior to melting of the coating.

Weirton uses an unusual temper mill arrangement, with a four-high stand to make the skin pass followed by a two-high stand to flatten the strip.





No. 5 electrolytic tin plating line operates at 2000 fpm. The entry end of the line includes an alkaline cleaner and a pickling unit.

An acid type plating solution is used, containing stannous chloride, various fluorides and other addition agents. Bath temperature varies, for the different weights of coating, between 135 and 155 F. A considerable amount of differentially coated tin plate is made wherein the tin coating is markedly different on the two sides of the strip. Thus, a heavy coating can be used for the interior of a can where extreme corrosion resistance is desired and a lighter coating for the exterior for ordinary atmospheric conditions.

Some characteristics of the electro-tinning lines are as follows:

	Plater current, amp	*Maximum speed, fpm*	*Capacity, base boxes per day, 0.75 oz coating*
No. 2	120,000	1400	15,800
No. 3	180,000	1400	16,600
No. 4	252,000	2000	22,500
No. 5	288,000	2000	22,600

Coiled tin plate is cut up on ten flying shear lines which operate at speeds up to 750 fpm. Another shear line cuts up zinc-coated strip.

There are also three hot dip tin pots to handle menders.

STEUBENVILLE PLANT

The fourth finishing area, which is also devoted to tin plate, is located in Steubenville, O., about five miles from Weirton. This was an old tin plate plant originally purchased in 1911 which now contains modern facilities for finishing cold reduced stock.

This plant now includes one electrolytic cleaning line with a capacity of 675 tons per day; eight radiant tube annealing covers for coils up to 54 in. in diam, giving a total capacity averaging 335 tons per day; two skin-pass mills which offer a daily capacity for 1175 tons; four cut-up lines which operate at 550 fpm and can handle 285 tons per day each; one batch type white pickler; and ten tin stacks giving capacity for 8100 base boxes per day.

The skin-pass mills are composed of a four-high stand followed by a two-high stand. One unit has a 9½- and 38- x 42-in. stand followed by a 26- x 42-in. stand, and operates at 2650 fpm. The other has an 8- and 32- x 38-in. stand followed by a 26- x 42-in. stand. It runs at 1450 fpm.

Coils from the cold reduction mills at the strip plant are brought to Steubenville in railroad cars. Finished tin plate is shipped direct from this plant.

DETINNING PLANT

To conserve tin and scrap, Weirton installed a detinning plant. Here, 5400 to 8400 lb of tin plate trimmings and scrap are put into a detinning drum, which is then placed into a tank and rotated for 2 or 2½ hr in a solution maintained at 24 to 27 oz per gal of caustic soda and 3.5 to 3.7 oz per gal of sodium nitrate. This solution is held at 200 to 210 F and gradually absorbs sodium stannate to the extent of about 1.6 oz per gal. Excess sodium stannate precipitates to the bottom of the tank.

The drum is drained and rinsed, and the scrap is dumped into storage and subsequently formed into bales of 550 to 650 lb for use in the open hearth.

Sodium stannate is recovered from the tank after about 27 charges of scrap have been detinned. Treatment with sulphuric acid converts the stannate to stannic hydroxide, which is filtered, dried, mixed with anthracite coal and reduced to metallic tin.

The detinning plant contains seven detinning tanks, two drying furnaces and two resistance type electric reduction furnaces which operate at about 2200 F. It will process about 66 tons of scrap per 8-hr turn.

Coils of tinplate from the electrolytic plating lines are cut up into the desired lengths on a battery of ten shearing lines.

PLANT SERVICES

Weirton is one of the largest users of oxygen in the steel industry. Two 25-ton oxygen units produce high purity (99.5 per cent) oxygen for the desurfacing unit at the blooming mill and for miscellaneous plant use. Some oxygen from this plant is bottled for use elsewhere in the plant.

There is also a 500-ton plant which produces 91.5 per cent oxygen which is used principally in the blast furnaces, with some to open hearth and converters.

Most of the electric power used in the Weirton plant is generated in the plant. Producing units include nine turbogenerators, four of which are high pressure units. The newest unit is a 20,000-kw, 13,800-volt, 3-phase, 60-cycle generator driven by a topping turbine operating on 800-psi, 800 F steam at a rate of 29 lb per kwhr.

There are also two other topping units, each of 10,000-kw, 80 per cent power factor, 6900-volt, 3-phase, 60-cycle rating, driven by a 3600-rpm, 800-psi, 800 F noncondensing turbine. These units average about 33 lb of steam per kwhr.

The three topping units exhaust into the 225-psi steam system, which supplies five 7500-kw, 6900-volt, 3-phase, 60-cycle generators, each driven by an 1800-rpm, 225-psi, 550 F condensing turbine. These units use 15 lb of steam per kwhr.

There is also a 25,000-kw, 80 per cent power factor, 13,800-volt, 3-phase, 60-cycle hydrogen-cooled generator driven by a 3600-rpm, 800-psi, 800 F condensing turbine. This unit operates on 9 lb of steam per kwhr.

All condensing equipment is of barometric type.

The five 7500-kw generators and the two 10,000-kw generators tie into the 6900-volt distribution system. The 20,000-kw and 25,000-kw units feed through transformers into the 23,000-volt distribution system. The two distribution systems are tied together through transformers.

With full operations, the Weirton plant may set up a 15-min power demand of 137,800 kw. Monthly consumption might run 78,573,000 kwhr, of which 69,000,000 kwhr might be generated.

The remainder of the power required is purchased from the utility company serving the area. This power comes into two principal substations at 132,000 volts. At the strip mill station, two 20,000/33,000-kva transformer banks reduce the voltage to 23,000 volts. At the tin mill station one 20,000/33,000-kva bank and one 15,000/20,000-kva bank step voltage down to 23,000. These two substations are also connected by 23,000-volt feeders.

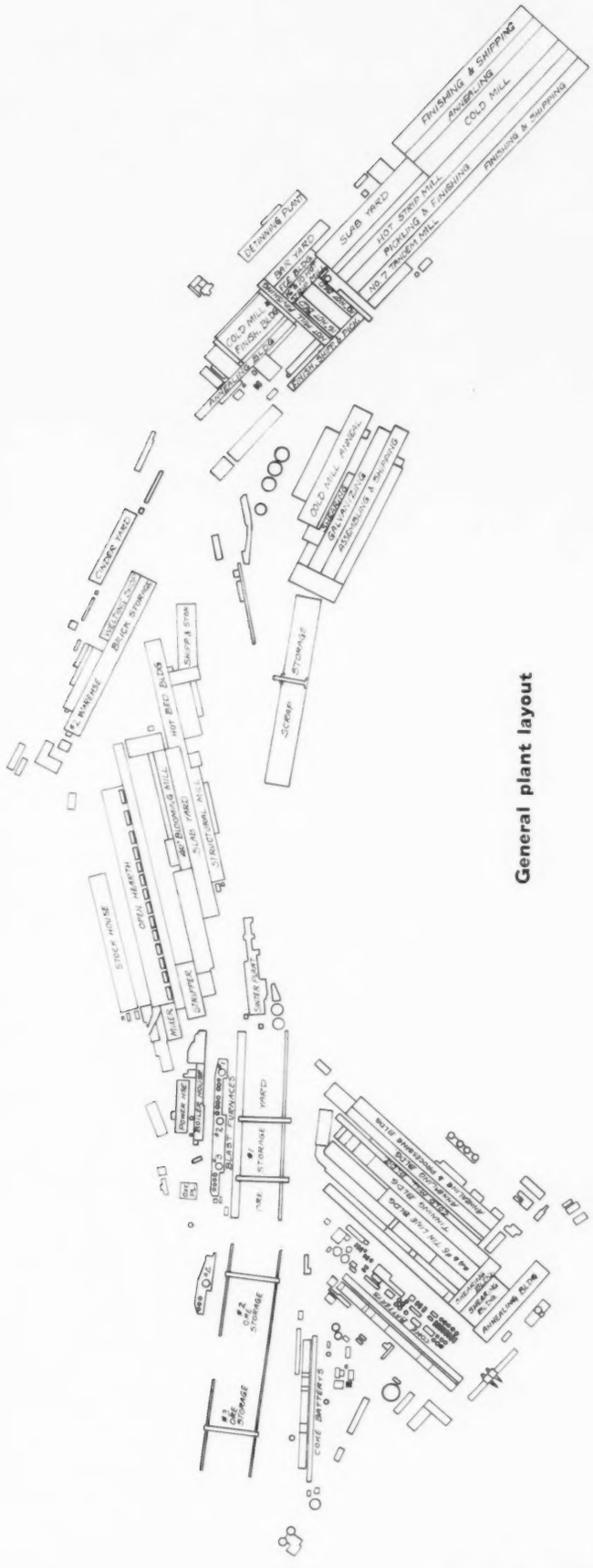
At principal load centers, the 23,000-volt power is stepped down to 6900 volts, which is principal operating voltage of the plant.

Steam for the high pressure system comes from five 850-psi, 825 F units, each rated at 325,000 lb per hr. They are four-drum units, with 20,487 sq ft of heating surface, 7900 sq ft of superheater surface, 4277 sq ft of water wall surface, and 49,500 sq ft of air preheater surface. They are fired with pulverized coal, blast furnace gas and coke oven gas, and have a combustion volume of 27,500 cu ft.

The 225-psi system receives steam from eight 900-hp boilers burning blast furnace gas or pulverized coal, one 125,000-lb per hr boiler fired with blast furnace or coke oven gas, and five 30,000-lb per hr units, of which four burn coke breeze on chain grate stokers and one burns coke oven gas.

The two steam systems are interconnected through two pressure reducing valves so that low pressure requirements, in excess of the supply from the topping turbines and from the low pressure boilers and the waste heat boilers at the open hearth, may be supplied from the high pressure system.

Total fuel used for steam generation in the Weirton plant per day consists of 1200 to 1800 tons of coal, 260 tons of coke breeze, blast furnace gas equivalent to



General plant layout

1300 tons of coal, coke gas equivalent to 180 tons of coal and open hearth waste heat equivalent to 275 tons of coal. Steam coal is trucked into the plant from nearby strip mines.

Water for the plant is pumped from the Ohio River in quantities of about 190,000,000 gal per day. This water is drawn through traveling screens by a battery of eight centrifugal pumps: two of 16,000 gpm, two of 22,000 gpm, two of 30,000 gpm, and two of 50,000 gpm.

Except for further straining at various points, no treatment is given the service water except that going to the tin mill, where a chemical clarification is used. Water for boiler feed is treated in hot process lime-soda softeners, followed by pressure filters, deaerating heaters and an auxiliary phosphate internal treatment. Since all condensing equipment is of barometric type, boiler feed is 100 per cent make-up.

Water from the barometric condensers at the powerhouse is subsequently recirculated to the blast furnaces, open hearth and rolling mills.

With full operation, approximately 11,000,000,000 gal of water (pumped and recirculated) are required per month.

At the north end of the plant are the river docks, with two warehouses. Here are the coal unloaders previously mentioned, a scrap dock where scrap is moved by magnet from barges to railroad cars, a tar loading station, and a dock where fuel oil and acid are pumped out of barges, and barges can be filled with benzol, etc. There are also two merchandise docks which can handle all types of material between barge, railroad car or warehouse floor.

In a typical year, total shipments at the docks (in and out) may total almost 3,500,000 tons. Incoming shipments may include 2,500,000 tons of coking coal, 35,000,000 gal of fuel oil, 300,000 tons of scrap (about 64 per cent of purchased scrap) and 8,000,000 gal of acid. Outgoing shipments might be 300,000 tons of steel products and 25,000,000 gal of tar.

Maintenance shops, including machine, electrical, blacksmith, carpenter, rigger, pipe, welding, etc., are located at the steel works, the strip mill and the tin mill, with the largest of each at the steel works, upon which the other shops may draw as necessary.

There are approximately 35 miles of standard gage railroad track in the Weirton plant. Railroad motive power includes 19 diesel locomotives (14 rated at 115 tons, two at 33 tons and three at 25 tons) and eight 50-ton diesel electrics. Four 40-ton diesel electric cranes and two steam cranes are also available. The plant has 127 hopper cars as well as numerous special cars for various specific uses.

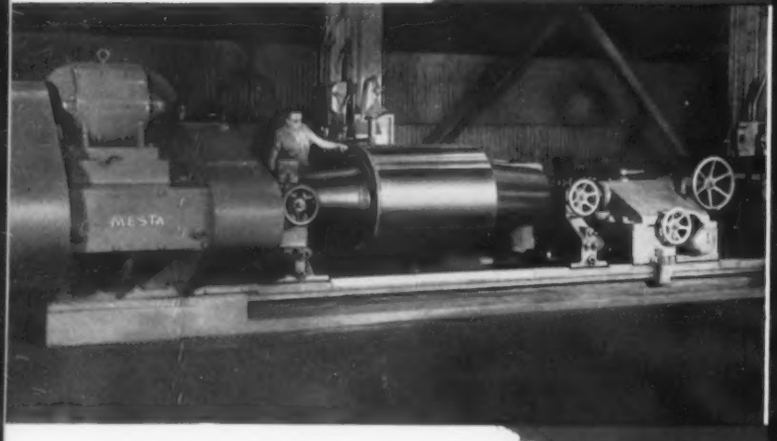
Motive power units, as well as many motor trucks used in the plant are equipped with two-way radio telephone.

Quality control in the manufacturing processes, from raw materials to the finished products, is the responsibility of the metallurgical and chemical departments. A modern building houses complete metallurgical and chemical laboratories, with excellent facilities for the tests and investigations necessary to insure fulfillment of customer requirements and to develop data to improve quality and production efficiency. Plant laboratories are also available in some of the major producing areas. ▲

Designed and Built by MESTA

Two Mesta 66" Continuous Pickling Lines with Flash Welders, Shears, Side Trimmers and Up-Coilers.

Mesta-Thomson Flash Welder in a modern, high-speed Mesta 56" Continuous Pickling Line.



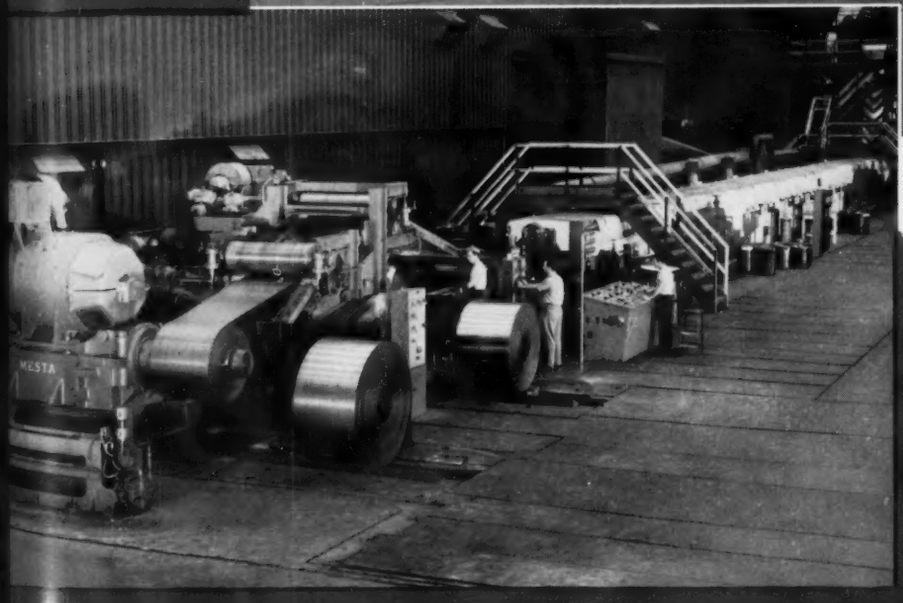
Mesta 60" Travelling Wheel Type Heavy Duty Roll Grinder Finishing a Backing-Up Roll.

Mesta 40" Two-High Reversing Slabbing-Blooming Mill.

for WEIRTON STEEL COMPANY

DIVISION OF

National Steel Corporation

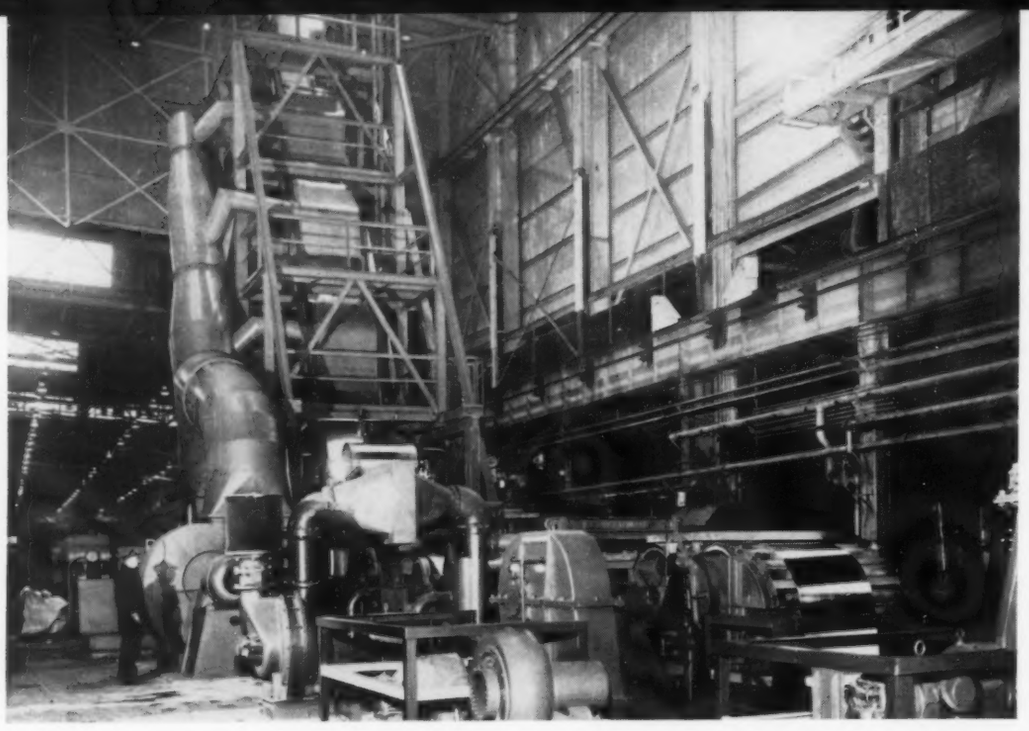


Mesta 2000 FPM Continuous Cleaning and Annealing Line for Steel Strip in Tin Plate Gauges with Pay-Off Reels, Mash Welder and Tension Reels.

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA



Congratulations to **WEIRTON STEEL COMPANY**

Congratulations to Weirton Steel Company, a Division of National Steel Corporation. Aetna-Standard was happy to furnish substantial equipment for this plant, including: two Continuous Galvanizing Lines, several Tin Plate Classifiers, and Sheet and Strip Processing Equipment.

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THE AETNA-STANDARD ENGINEERING COMPANY

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Steel men "in the know" are lowering maintenance costs with Dorco® guide bars, slippers, screw down nuts and other heavy bronzes. These men are able to schedule their down-time because of dependably longer service life of Dorco's higher quality steel mill bronzes. As specialists in this field for over a dozen years, our engineers can help **YOU** solve **YOUR** maintenance problems.

We are proud to number the divisions of National Steel Corporation as regular users of Dorco products, along with eleven others of the fifteen largest American steel producers from Pennsylvania to California.

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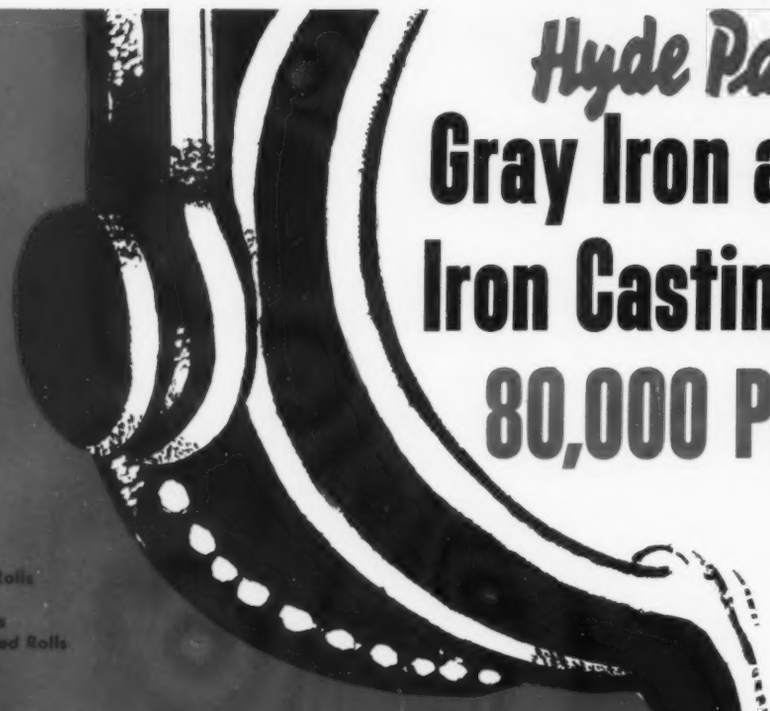

ROLLS

Alloy Iron Rolls
Grain Rolls
Chilled Rolls
Nickel Chilled Rolls
Moly Rolls
Cold Rolls

ROLLING MILL EQUIPMENT

Bar Mills
Merchant Mills
Sheet and Strip Mills
Pinion Stands
Roller Tables
Reduction Drives
Stretcher Levellers
Guillotine Shears
Sheet Mill Shears
Roll Lathes
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We have been making miscellaneous Castings for

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for over
Twenty Years!

Our foundry and machine shop facilities are equal to any of your requirements.

Castings up to 80,000 pounds—

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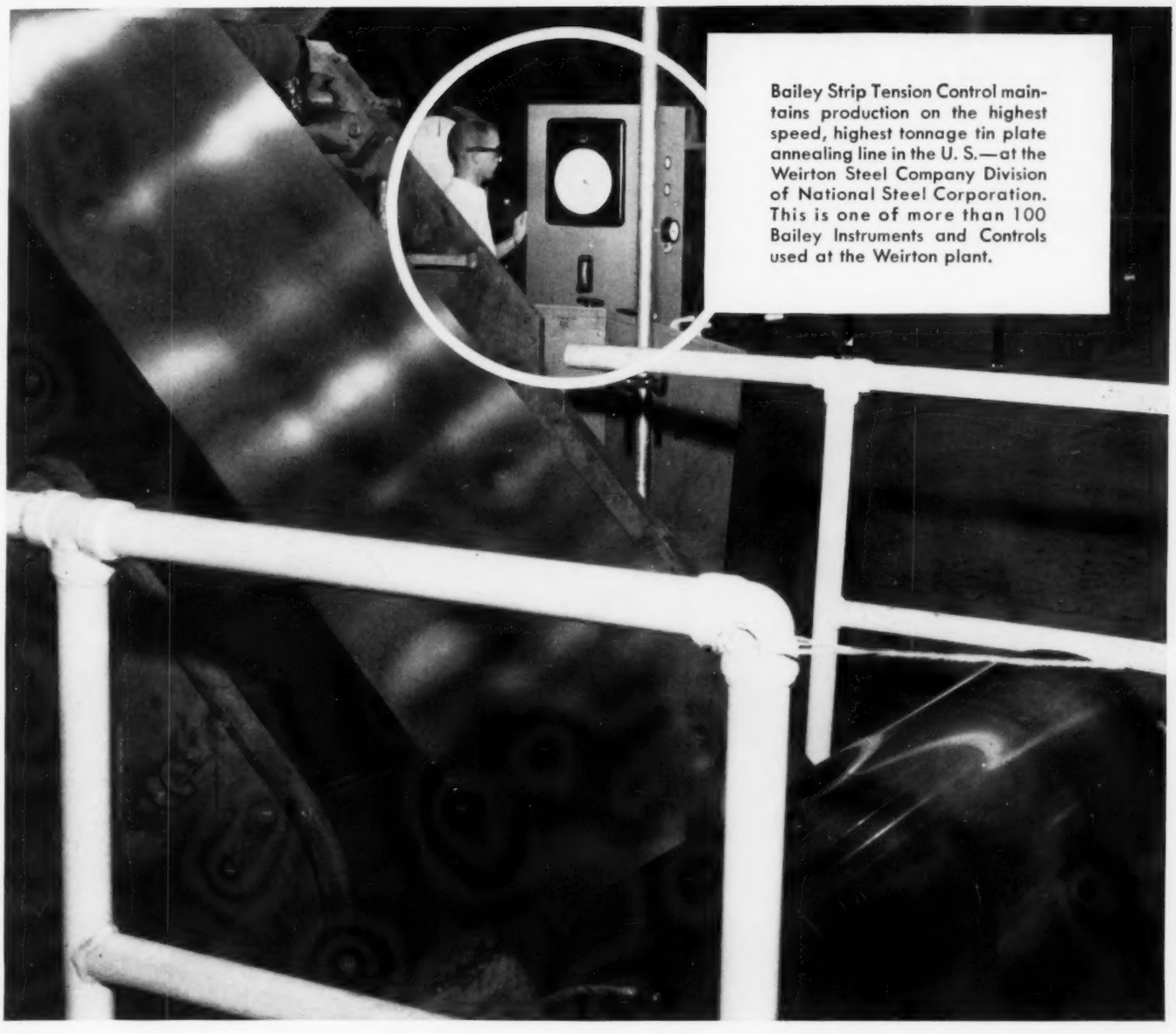
Hyde Park **FOUNDRY & MACHINE CO.**

HYDE PARK, WESTMORELAND COUNTY, PITTSBURGH DISTRICT, PA.



Bailey Strip Tension Control maintains production on the highest speed, highest tonnage tin plate annealing line in the U. S.—at the Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls used at the Weirton plant.

Strip keeps rolling when Bailey keeps an eye on it

Installing Bailey Strip Tension Control will cost you far less than a single strip breakage in a furnace due to poor tension control . . . and it's the surest way of ending tension problems.

Strip tension at speeds up to 2000 feet per minute is pre-set, controlled, and recorded by this unique system. Bailey S.T.C. eliminates undue instantaneous strains through natural 'cushioning' of pneumatic control. It helps maintain strip flatness during finishing operation by minimizing slack formations, and it simplifies strip tracking by holding tension within allowable limits.

If you roll strip, see your Bailey Engineer about Strip Tension Control, or write the Iron and Steel Division for more information.

S114-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

MEAD-MORRISON equipment

The Mead-Morrison Division of the McKiernan-Terry Corporation is proud to have had a part in the expansion of the Weirton Steel Company, division of National Steel Corporation, and wishes to take this opportunity to thank our friends at Weirton for their continued confidence in our equipment.

The photos below show the major pieces of Mead-Morrison equipment installed at Weirton, W. Va. The barge unloading tower in the background of the photo at the left has been in operation for about 32 years. Its sister tower, in the foreground, has just been placed in operation. In addition to the Mead-Morrison features found on both towers, the new tower incorporates our new patented progressive reeving system which uses one continuous rope for the hold and close lines, adjustable voltage control and a liquid dust suppression system developed by Mead-Morrison. The new tower has a free digging capacity of 635 tons of coal per hour and feeds into the same conveyor system as the older tower.

The traveling, scrap handling bridge in the center photo has also been in operation for about 32 years and is a rope trolley type equipped with a magnet. A year ago a new protected pier leg sill, new trucks and automatic hydraulic rail clamps were installed on the bridge. Each rail

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MEAD-MORRISON division of

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W-68

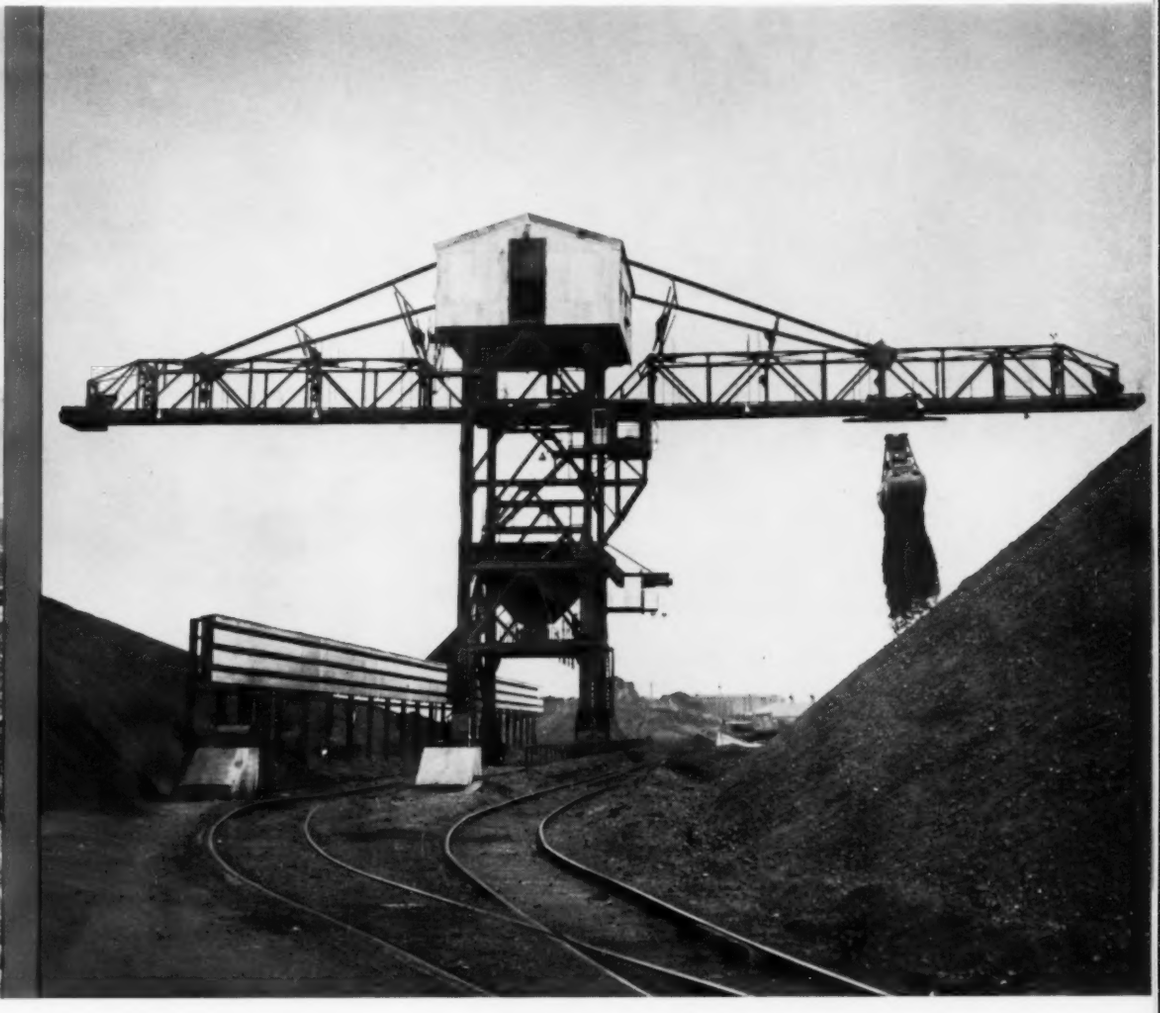
at work at Weirton Steel

clamp incorporates a compression type spring that forces the large coarse teeth of the clamp shoes to bite into the sides of the rail head. The clamp is released by hydraulic pressure only when the bridge is being propelled.

The photo at the right shows the Mead-Morrison traveling tower installed in the coal storage yard in 1952. Coal is brought to the yard in cars which dump into a digging trough alongside the tower. The tower digs coal from the trough and delivers it to the near-side stocking pile at the rated capacity of 915 tons per hour, and to the far-side stocking pile at the rated capacity of 610 tons per hour. It reclaims coal from either storage pile to the receiving hopper in the tower at the rated capacity of 765 tons per hour. Included in the many Mead-Morrison features are a 6½ ton lightweight grab bucket and automatic rail clamps. Adjustable voltage is used for the hoist, close and trolley motions, and constant voltage for the propelling motors. All shop and field connections in the main structure are welded. The connections in the cantilevers are riveted.

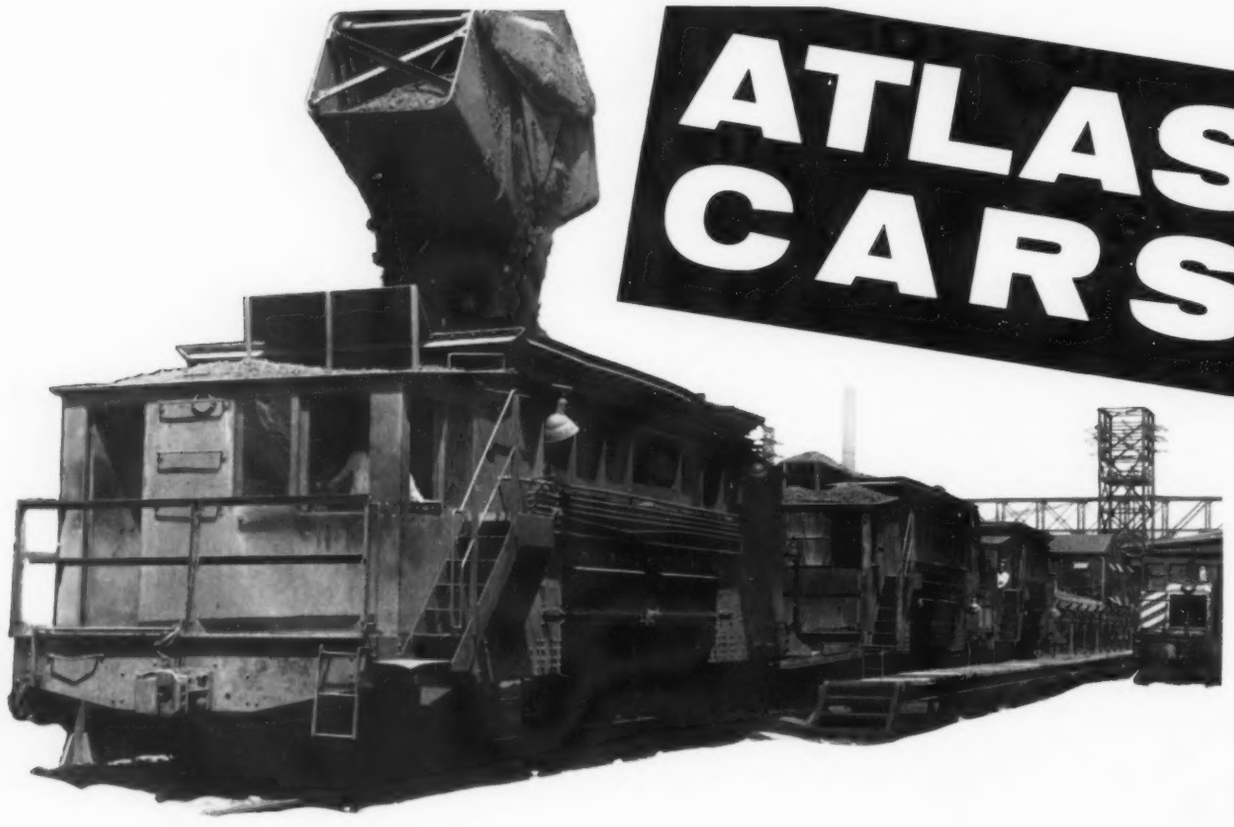
In addition to the equipment shown in these photos, Mead-Morrison supplied the Weirton Steel Company with car and barge haul systems.

May we help you solve your bulk material handling problems?



McKIERNAN-TERRY CORPORATION

WESTERN SALES OFFICE: 7 SOUTH DEARBORN STREET, CHICAGO 3, ILLINOIS



ATLAS CARS

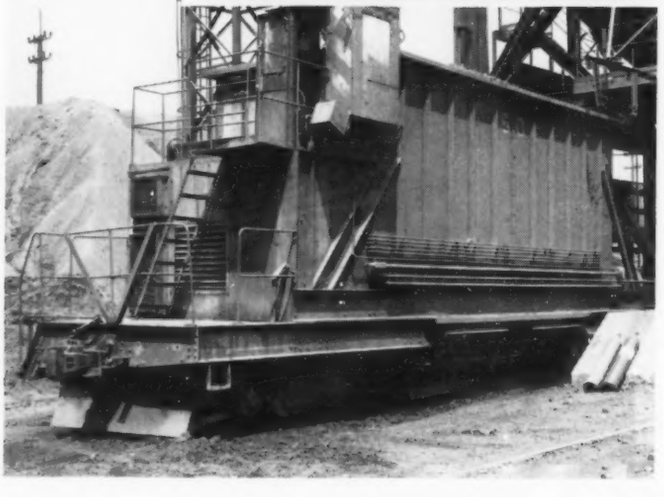
AT WEIRTON

The special purpose cars shown here were designed and built to meet the exacting needs of steel plant service. Simplicity and ruggedness contribute to their dependability.

75-Ton Ore Transfer Cars

One of the Stockhouse Scale Cars

Diesel-Electric 60-Ton Coal Transfer



Since 1896 . . . Engineers—Builders of Ore Transfers . . . Scale Cars . . . Coke Quenchers . . . Coal Larries . . . Door Machines . . . Safety-Type Transfers . . . Storage Battery Locomotives

ATLAS

CAR & MFG. CO.

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CLEVELAND 10, OHIO

W-70

JONES HERRINGBONE REDUCERS DRIVE BIG SINTER MACHINES AT EXPANDED WEIRTON PLANT

In the recently enlarged and modernized sintering plant of Weirton Steel Company, a division of National Steel Corporation, Jones herringbone speed reducers were selected to drive some of the largest sintering equipment ever built. A size 440 DHA reducer, 47:1 ratio, drives a 12 ft. sinter breaker from a 75 hp. motor. A size 540 THA reducer, 88:1 ratio, drives a 12 ft. sinter machine; while an identical reducer drives a 10 ft. sinter cooler. Elsewhere throughout the plant, Jones reducers are used for most of the conveyor and machinery drives.

There are a number of reasons why steel mill men prefer Jones herringbone reducers. Engineers like the design which "anchors" the low-speed shaft to take heavy thrust loads, yet lets the other shafts float endwise on roller bearings to equalize loads and give full face contact on the gear teeth. Maintenance men like the simple, rugged construction which means easy servicing and minimum down-time. Purchasing officials like the wide range of standard types and ratings of Jones reducers, which lets them select the right unit for the job at lowest cost.

In fact, Jones now offers one of the industry's broadest lines of speed reduction equipment. Whether you need herringbone, worm, worm-helical, or spiral bevel reducers . . . shaft-mounted reducers . . . in-line helical reducers . . . or a complete line of gearmotors—you can make Jones your power transmission headquarters. For information or service, contact your local H-R representative, or Hewitt-Robins, Stamford, Connecticut.

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INDUSTRIAL HOSE . . . VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

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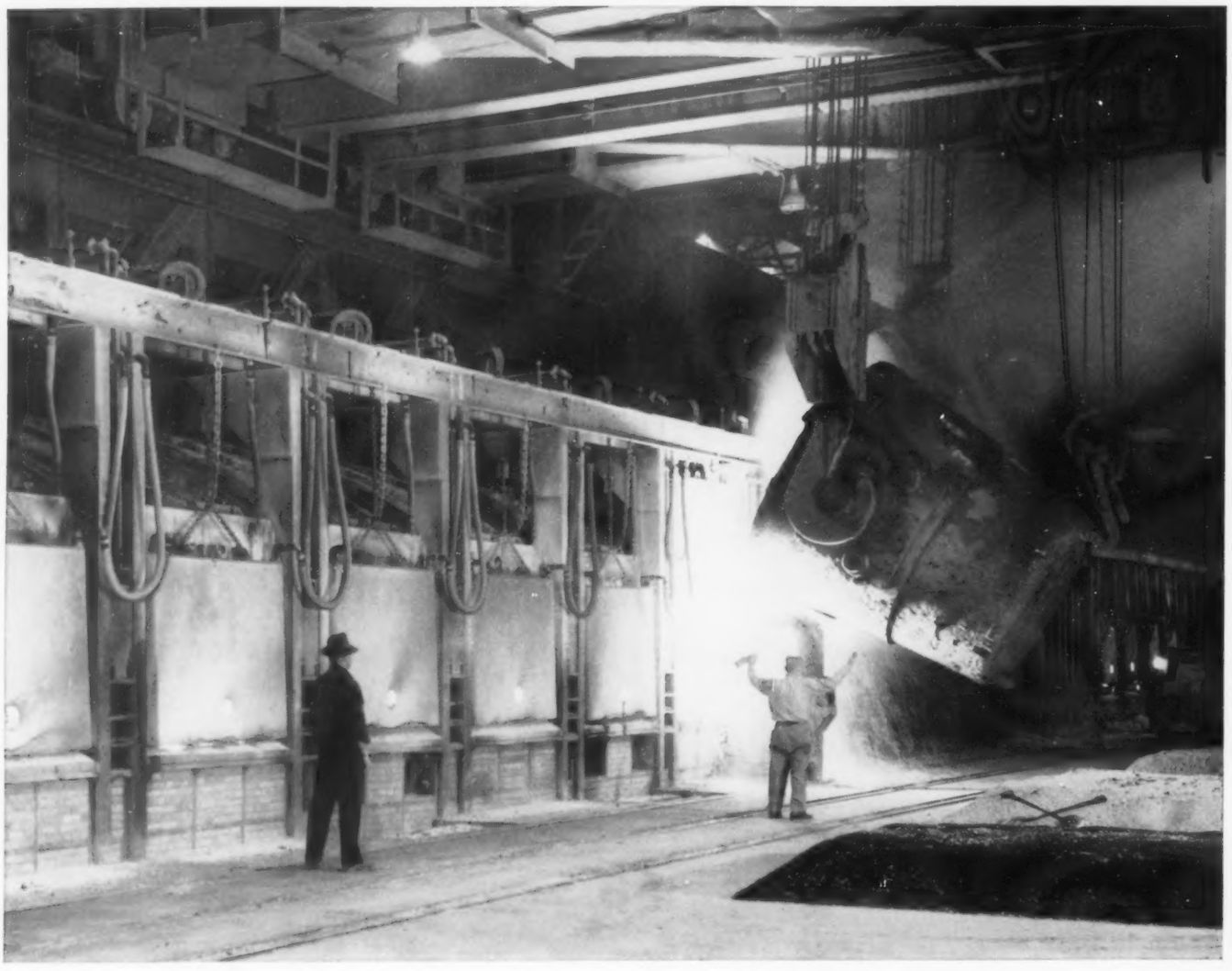


WORLD'S LARGEST OPEN HEARTH FURNACE

Designed and Built By Loftus

The largest known open hearth furnace in the world is located at Weirton Steel Company, Division of National Steel Corp., Weirton, West Virginia.

Designed and built by Loftus Engineering Corp., this huge furnace has a rated capacity of 600 tons, is approximately 111 feet long by 30 feet wide, and construction was completed in less than a year. Operation is simple since the furnace is equipped with full automatic control.

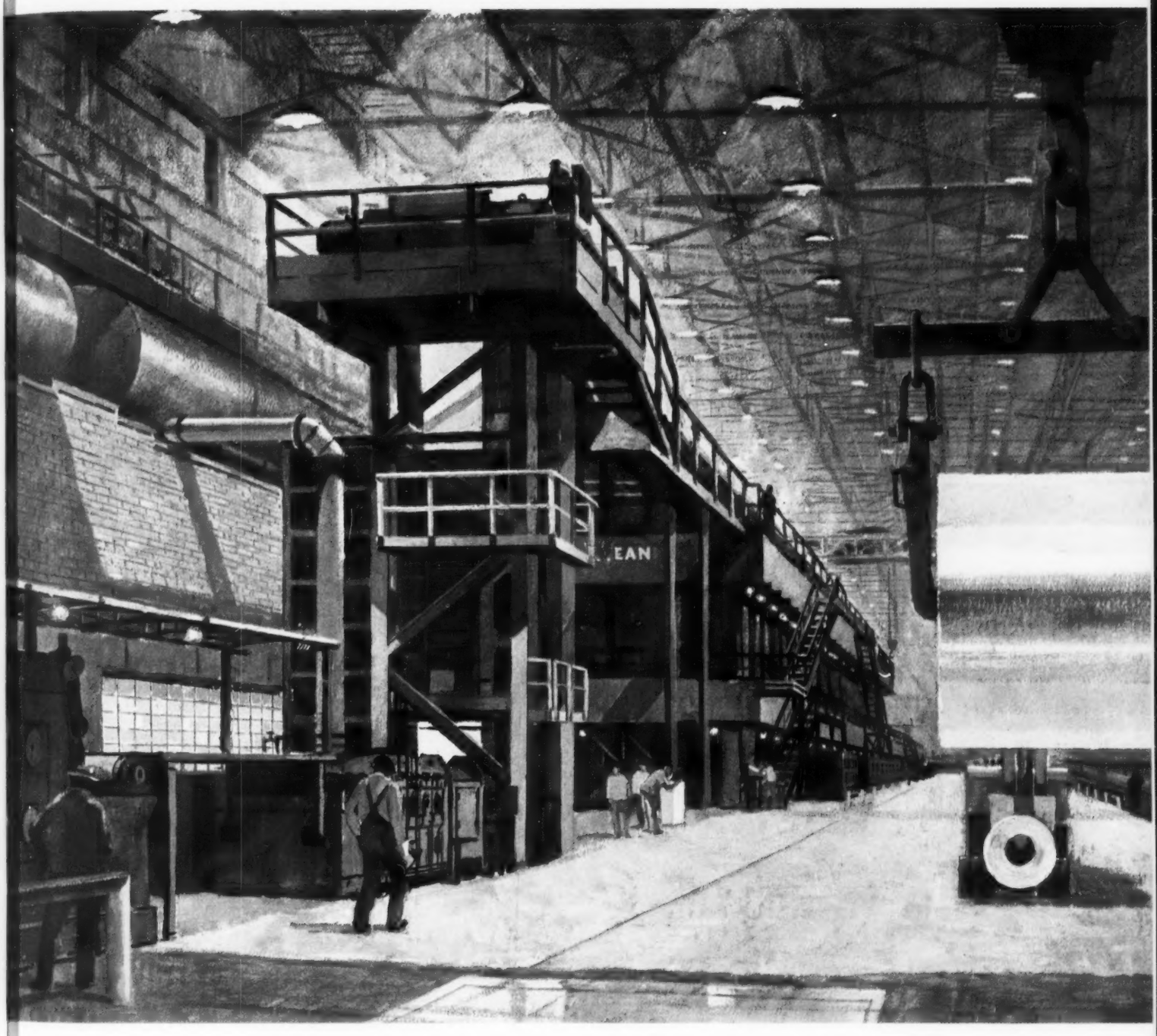
If you are planning expansion or modernization of your heating facilities (ferrous or non-ferrous), we would like to demonstrate how Loftus' long experience in furnace design and construction can benefit you. Write us today. There is no obligation.

From first heat to heat treat, look to **LOFTUS**

Engineering Corporation

1 Gateway Center, Pittsburgh, Pa.

Wean, Weirton and Tinning . . .

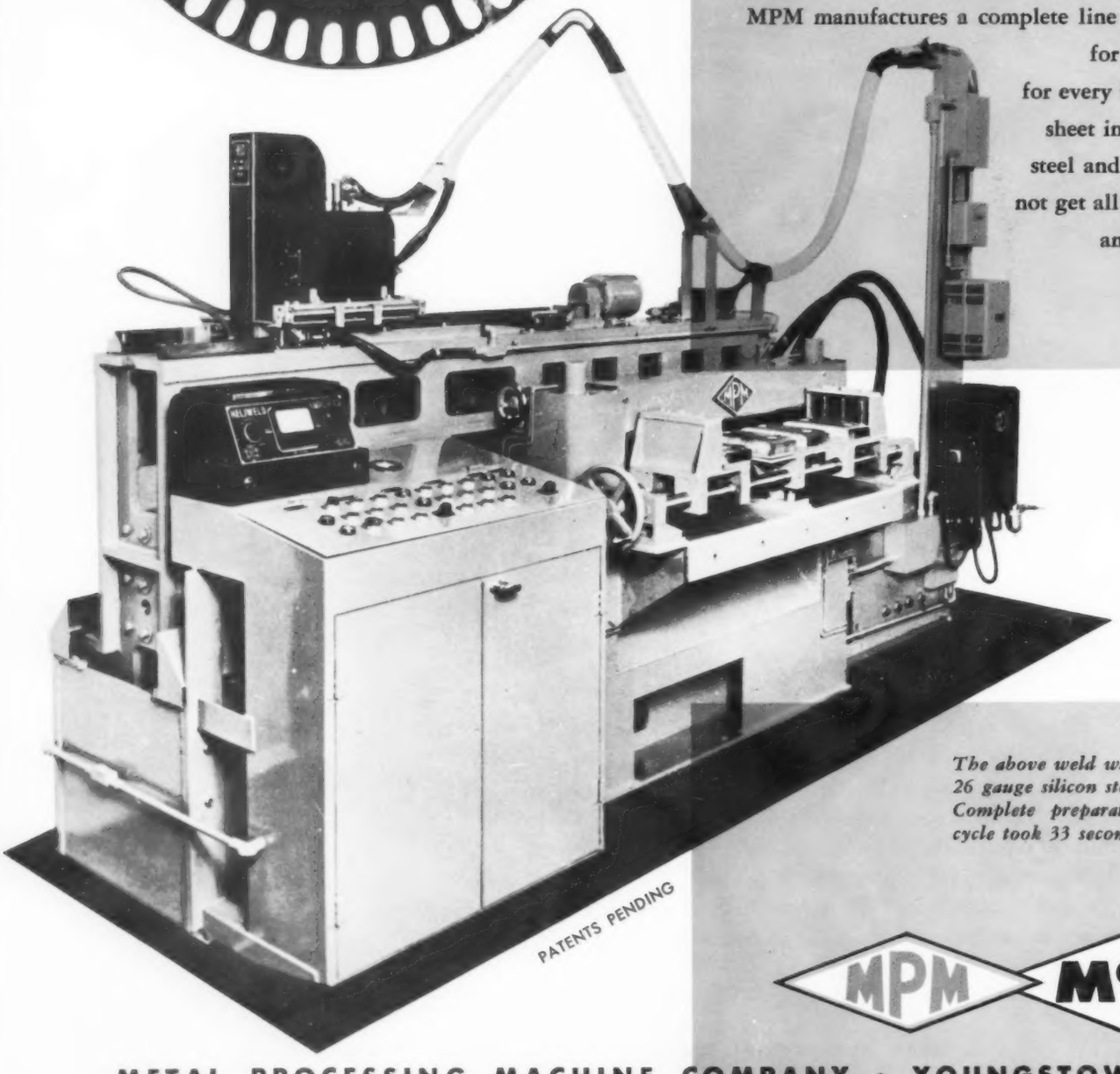


More than a city block long, this electrolytic tinning line is a true test of engineering precision. Through this line a continuous ribbon of steel travels at speeds up to 2000 fpm while being coated with a uniform layer of tin 30 millionths of an inch thick.
A Wean line is engineering precision at its best. Wean has engineered and constructed 47 electrolytic tinning lines.
These lines account for more than 75% of America's annual electrolytic tin plate production.

THE WEAN ENGINEERING COMPANY INC. • WARREN • OHIO

Silicon steel coil buildup made faster, more accurate by amazing MPM shearwelder

● The unretouched photo of the rotor lamination is a typical production butt-weld made on 26 gauge silicon steel by MPM's outstanding new Shearwelder. Perfect welds like this are a result of the exclusive positive guiding and clamping arrangement and welding technique developed by MPM engineers. Both shearing and welding are performed at the same station eliminating the chance for error that occurs when the work is moved from station to station, too, this MPM method speeds the operation. MPM manufactures a complete line of Shearwelders for every need, and for every type of strip and sheet including stainless steel and tin plate. Why not get all the facts on this amazing machine?

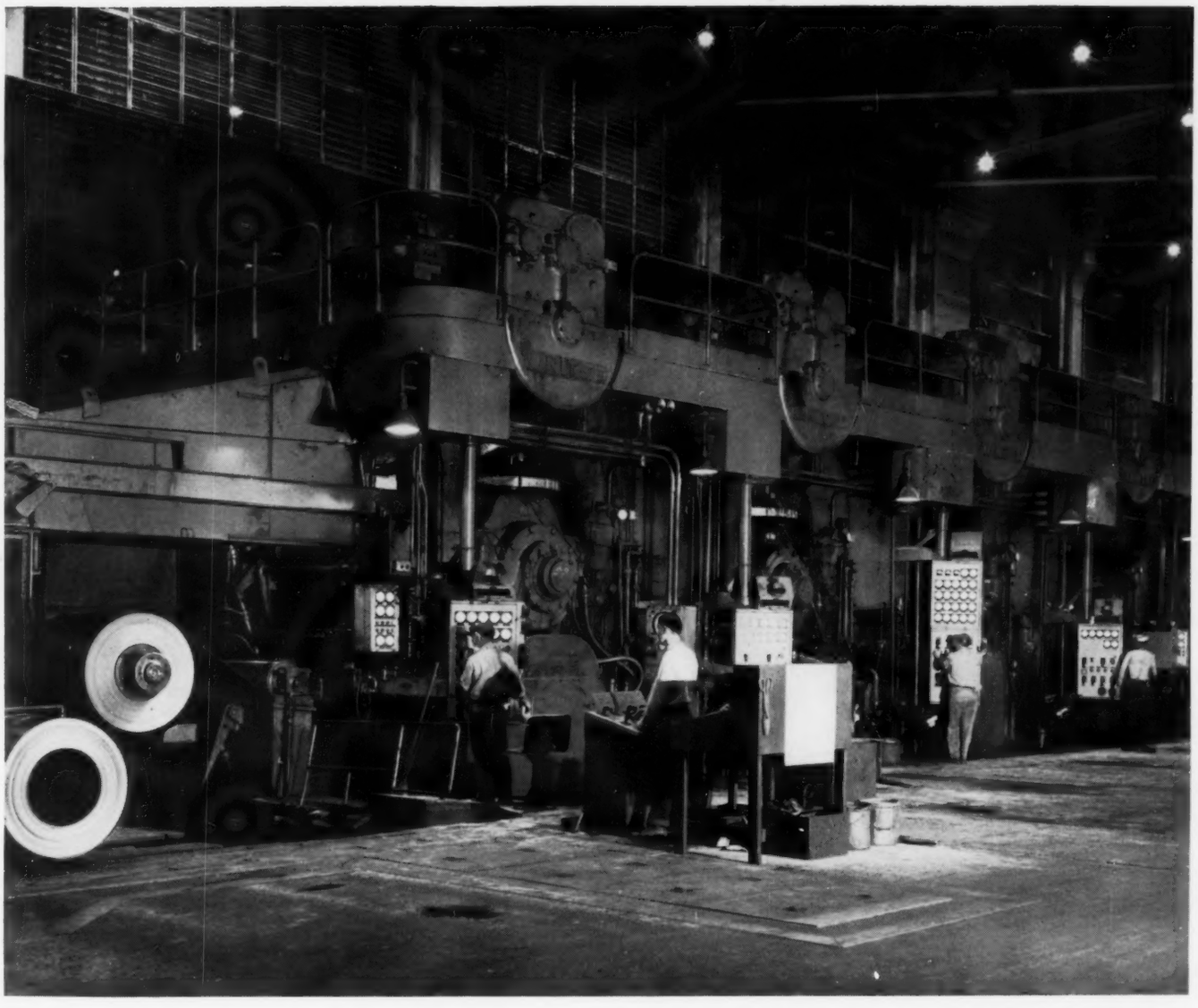


The above weld was made in joining 26 gauge silicon steel sheet 33" wide. Complete preparation and welding cycle took 33 seconds.

MPM McK

METAL PROCESSING MACHINE COMPANY • YOUNGSTOWN, OHIO

Subsidiary of THE McKAY MACHINE CO.



Weirton equips cold strip mill with double-poured Ni-hard working rolls

Ni-Hard nickel-chromium cast iron provides hardness of 80 to 82 Shore . . . provides long life, consistently good finish

Weirton Steel Company, a division of National Steel Corporation, is using double-poured Ni-Hard* nickel-chromium alloy iron working rolls on all five stands of its cold strip mill. These Ni-Hard rolls are 23-inches in diameter with a 52-inch face. Six stands in Weirton's hot strip mill are also equipped with Ni-Hard rolls.

Why Ni-Hard working rolls? Ni-Hard cast iron possesses a matrix structure in the mold cooled condition that is akin to that of heat treated steel. In addition, it contains a multitude of refined carbides which make an important contribution to its abrasion resistance. The resulting structure has great hardness, strength, and resistance to impact.

For your applications. Ni-Hard alloy possesses the fluidity and freezing range of the cast irons and can be readily cast in all forms and shapes common to the iron and steel foundry. If you'd like specific information concerning its application to your abrasion problem, write Inco. For details on double-poured Ni-Hard rolls, write the fabricator, United Engineering Company.

*Registered trademark

The International Nickel Company, Inc.
67 Wall Street INCO New York 5, N. Y.

NI-HARD

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

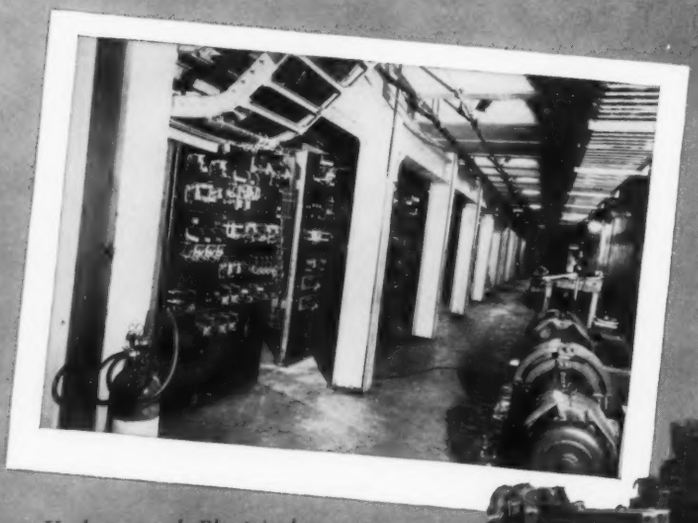
STEEL GROWS IN WEIRTON'S

EXPANSION & MODERNIZATION PROGRAM

• In keeping pace with demands for increased steel capacity Weirton Steel Company Division, National Steel Corporation has recently set in operation two completely new continuous strip galvanizing lines at Weirton, West Virginia.

Equipped with the latest machinery, these lines can operate at speeds up to 400 feet per minute, galvanizing up to 10 gauge strip from 20 to 50 inches in width.

Galvanized steel coils literally "grow" from these lines.



Underground Electrical Equipment Room

WEIRTON STEEL COMPANY

NATIONAL STEEL

The first of two 480 ft. long continuous strip galvanizing lines.

• The Murray Organization is proud of its share in Weirton's expansion program.

This comprehensive installation, including construction and installation design, demonstrates how Murray men and materials execute their projects.

If you want outstanding performance in design and engineering for complete turnkey installations, write

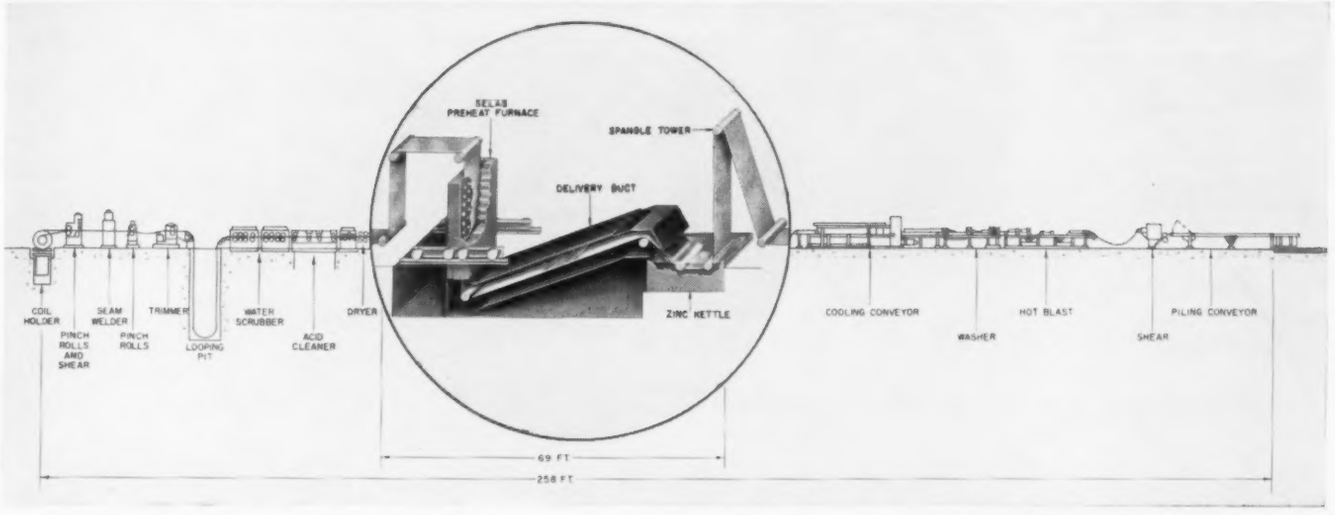
DAVID W. MURRAY COMPANY

DETROIT • TOLEDO • CLEVELAND • PITTSBURGH
MAIN OFFICE • P. O. BOX 4768 • CLEVELAND 26, OHIO

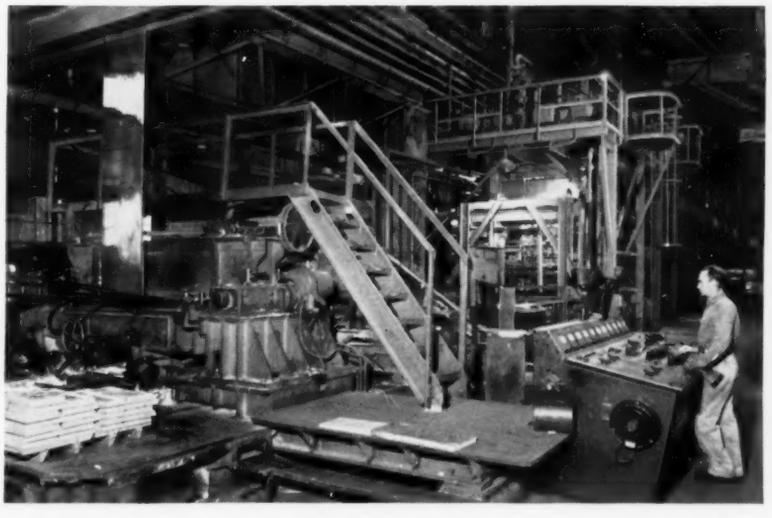
our research is your reward

ONLY ONE NEW KETTLE IN 4 YEARS

with Selas preheat for continuous strip galvanizing



151,000 TONS OF GALVANIZED STRIP BEFORE REPLACING KETTLE! Selas Gradiation® unit, consisting of furnace and delivery duct, replaced fluxing and drying equipment; was fitted into the 69 feet available between strip cleaning and spangle tower. Furnace accommodates strip from 18 to 30 gage, from 24 to 48 in. wide, at speeds from 56 to 225 fpm.



Weirton Steel Company, a division of National Steel Corporation, has extended kettle life and eliminated downtime for kettle repairs on its No. 1 galvanizing line through the use of this unusual Selas strip preheating furnace. One kettle produced 151,000 tons of coated strip!

Weirton formerly fired the kettle externally. The strip was partially preheated and fluxed by conventional methods. In the presence of the flux, the aluminum (added to the bath to improve adherence) attacked the kettle at an alarming rate, shutting down the line for kettle repairs every few weeks.

This problem was solved by a unique approach to continuous galvanizing . . . that of employing preheated strip to maintain the temperature of the molten zinc.

The Selas furnace preheats the strip to 950°F, thus eliminating all kettle firing during line operation. The strip supplies enough heat to hold zinc bath temperature at 850°F, although zinc slabs are added to the bath without premelting. In addition, by preheating without oxidation, this direct-fired furnace eliminates the need for fluxing.

Since the start-up of this Selas preheat furnace in 1954, Weircoloy, the product of Weirton No. 1 galvanizing line, has demonstrated its ability to take the severest draw or bend without cracking or peeling the coating. Furthermore, monthly production has been increased 30%.

Most important, the first kettle used with Selas preheat was replaced in July 1957, after production of 151,000 tons of coated strip with no downtime for kettle repairs. The second kettle is still going strong!

Perhaps the concept and technique of Gradiation heat processing—engineered by Selas—can help you solve steel mill or metalworking problems. Write for reprint giving full details of this Weirton installation and Bulletin S1056 "Selas Gradiation Heating in the Steel Mill." Address Dept. 411, Selas Corporation of America, Dresher, Pa.

Gradiation is a registered trade name of Selas Corporation of America.

SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION

A typical CCC "Task Force" Unit headed by J. C. McLure, Project Coordinator. On his left E. C. Sawyer, Estimating Engineer; U. A. Strang, Director-Purchasing and C. M. Wasson, Company Pilot. On Mr. McLure's right C. J. Duke, Superintendent-Operations; Q. C. Clark, General Superintendent and his Assistant Superintendents L. A. Watson and F. Cangemi.

Routine CCC task force report . . .

"Two continuous galvanizing lines totaling 143 pieces installed on schedule at new Weirton Steel* Plant"

"On schedule" performance is a business habit with Commercial Contracting Corporation.

Using "task force tactics" on all their machinery moving and installation jobs, CCC has set new performance standards in a highly specialized business. A CCC task force unit is a self-sufficient team capable of completing an entire job without assistance. When needed, a twin engine airplane is available to help keep the job "on schedule."

A CCC spokesman says, "The task force approach is the only positive method we have of tying together the hundreds of details in the installation of complicated machinery. Delays boost the price of the equipment. By maintaining or beating schedules we make money for our customers."

CCC's reputation for dependable service is well known, not only in the steel industry, but in other basic metals fields as well.

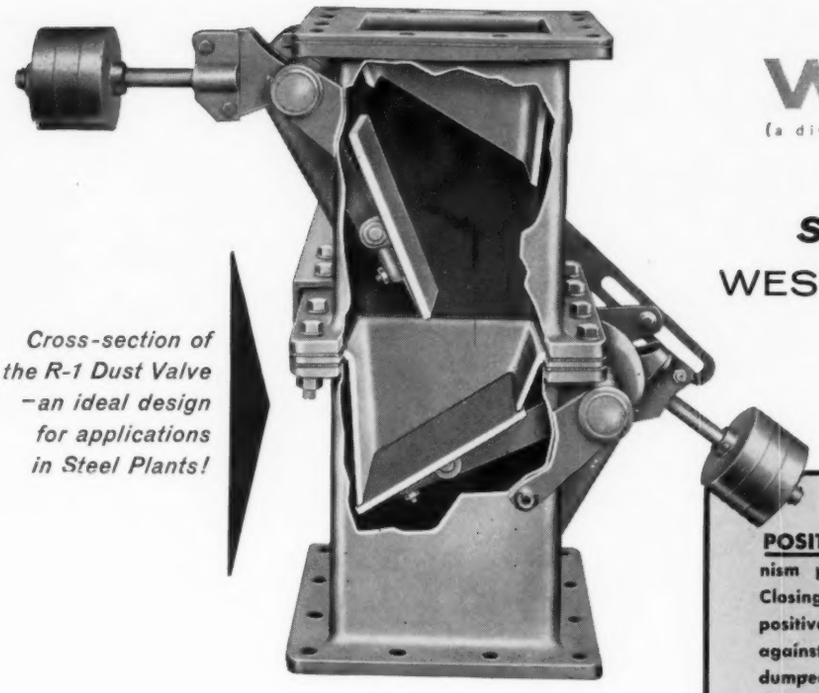
CCC services include press erecting, rolling mill installation, automated machinery installation and moving, foundry and overhead crane installations.

Installing industrial machinery is not a do-it-yourself project. It's a job for COMMERCIAL CONTRACTING CORPORATION. Write to 12160 Cloverdale, Detroit 4, Michigan or call TExas 4-7400.

Exit end of Weirton's two new continuous galvanizing lines showing equipment in final installation stage.

**Division of National Steel Corporation*

CCC
COMMERCIAL
CONTRACTING
CORPORATION



Cross-section of the R-1 Dust Valve – an ideal design for applications in Steel Plants!

WEIRTON

(a division of National Steel Corporation)

IS **ANOTHER*** ***Steel Company using*** WESTERN PRECIPITATION DUST VALVES!

POSITIVE ACTION: Electric motor-driven mechanism provides positive opening on time-cycle basis. Closing is by gravity — and is adjustable. Thus, valve positively opens even with lightweight materials or against high vacuum . . . closes only after material is dumped.

DOUBLE-FLAP SEALS: Two flaps open and close alternately on a positive cycle to insure continuous clean-out without allowing pressure surges into hopper.

GRAVITY FLUSHING: Gravity safety trip permits each flap seal to open automatically if overloaded, allowing flush-out of excess material. Valves then return automatically to time-cycle operation.

RUGGEDLY BUILT: All parts and seals are designed for heavy-duty service with minimum maintenance. Bearings are sealed against dust — are outboard-mounted to protect against heat and dust. Valve seats and flap seals are easily replaced. Motor is fully sealed and protected.

There are many other unique features your Western Precipitation representative will gladly explain. Or write direct!

No dust recovery installation is better than the valves controlling the dust flow out of the collection hopper — particularly in Sintering Plants where the system operates under substantial vacuum. Poorly designed valves allow recovered dust to blow back into the system . . . cause troublesome draft losses . . . air infiltration . . . and cut down efficiency of even the best recovery systems.

But throughout the steel industry — as in many other fields of industry — the Western Precipitation R-1 Dust Valve is setting entirely new performance standards for trouble-free operation and maximum working efficiency. Outlined at right are a few of the many reasons you, too, will find R-1 Dust Valves superior . . .

R-1 Dust Valves are only one of a wide range of automatic dust valves available from Western Precipitation for various types of applications. These valves are another development of Western Precipitation's more than a half-century of leadership in the highly technical field of modern dust, fume and fly ash collection. If it's a gas cleaning problem, let our experienced engineers make suggestions to fit your particular requirements. No obligation, of course!

* To date 15 steel companies have installed R-1 Valves . . . and every company has re-ordered additional installations!

WESTERN

PRECIPITATION

CORPORATION

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Jet-Cleaned Filters
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Engineers and Constructors of Equipment for Collection of Suspended Material from Gases . . . and Equipment for the Process Industries

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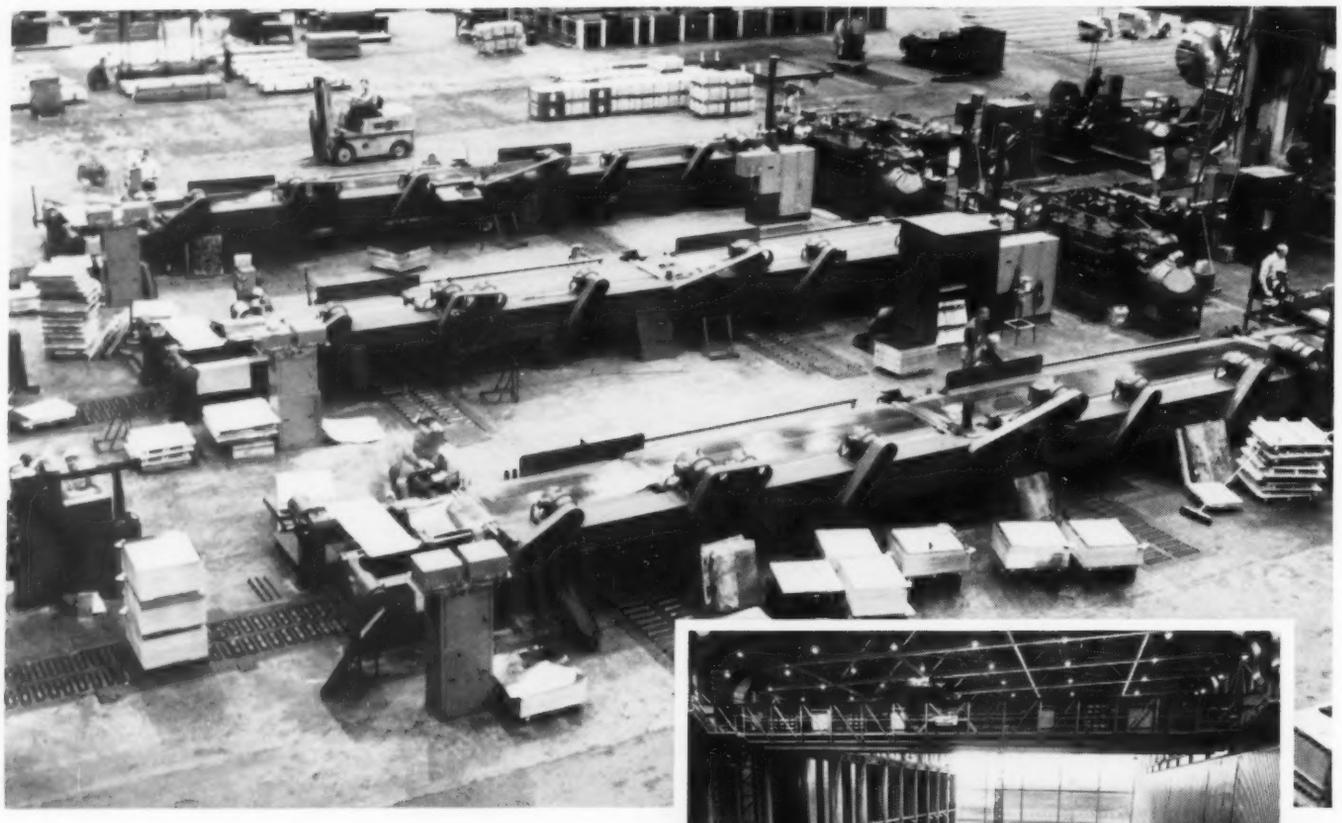


As a prime contractor, the Howard P. Foley Company constructed four tin shearing lines, a Weirzin line and 13 overhead cranes at the Weirton Steel Company, division of National Steel Corporation. Shown above are three of the tin shearing lines. Insert photo shows one of the overhead cranes.

In Industrial Construction . . .

Single Supervision Cuts Costs

THE HOWARD P.

FOLEY

COMPANY

228 ISABELLA STREET • PITTSBURGH 12, PA.

It makes good common and corporate sense to enjoy the benefits of the single supervision offered by a turnkey contractor when you require industrial construction.

You save money because there is only one contractor with one overhead instead of several contractors, each with duplicating costs, working for you.

You eliminate inconvenience because there is one firm responsible for the entire project instead of a contractors' convention which often takes up the valuable time of your management team.

You reduce costly construction delays because your turnkey contractor handles mechanical and electrical construction, rigging and setting of associated equipment and all materials in one smooth, coordinated operation.

Our organization is best for you because of its efficient size, wealth of experience and record of satisfied clients.

Call us today . . . we're only seven turns of a telephone dial away from you with ten offices throughout the country.

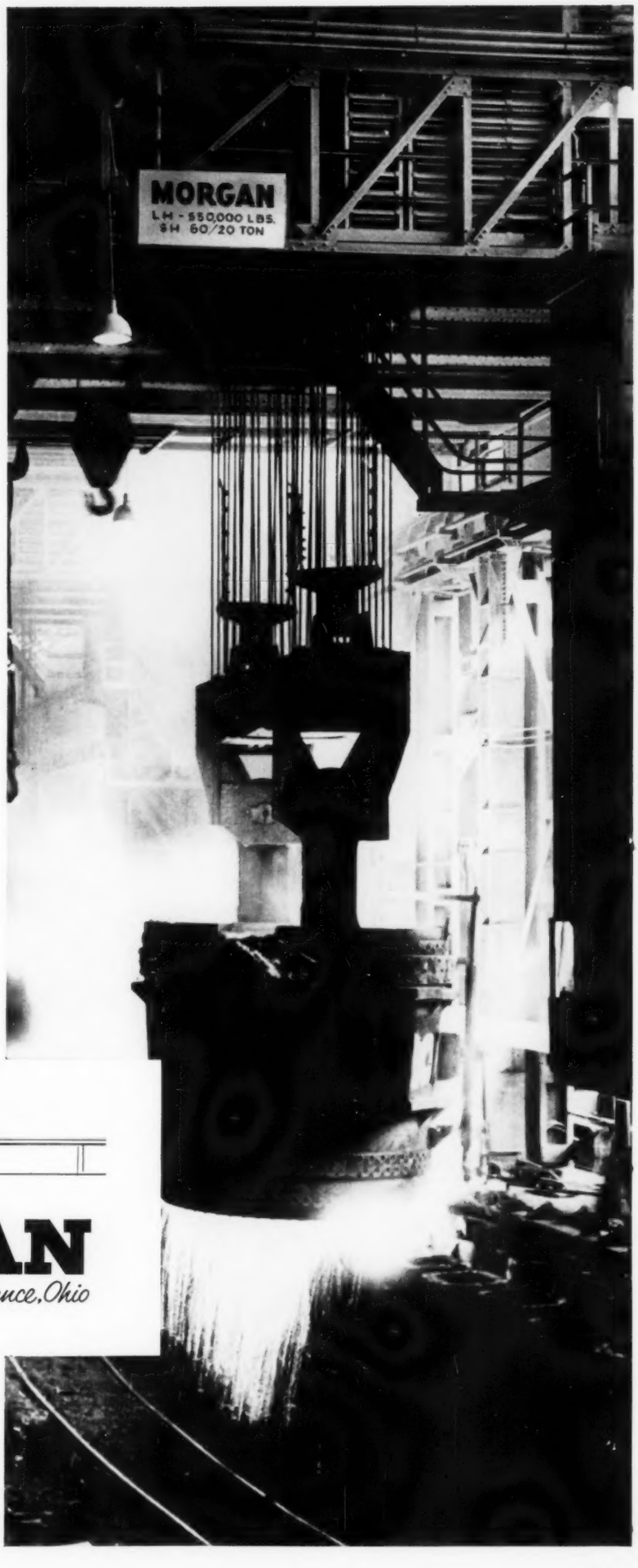
IT PAYS TO ORDER A "MORGAN"

Weirton proves it over 85 times

Leading steel producers like Weirton Steel Company, Division of National Steel Corporation, have firsthand evidence that Morgan cranes pay off. This proof of performance has led Weirton to order more than 85 Morgan cranes.

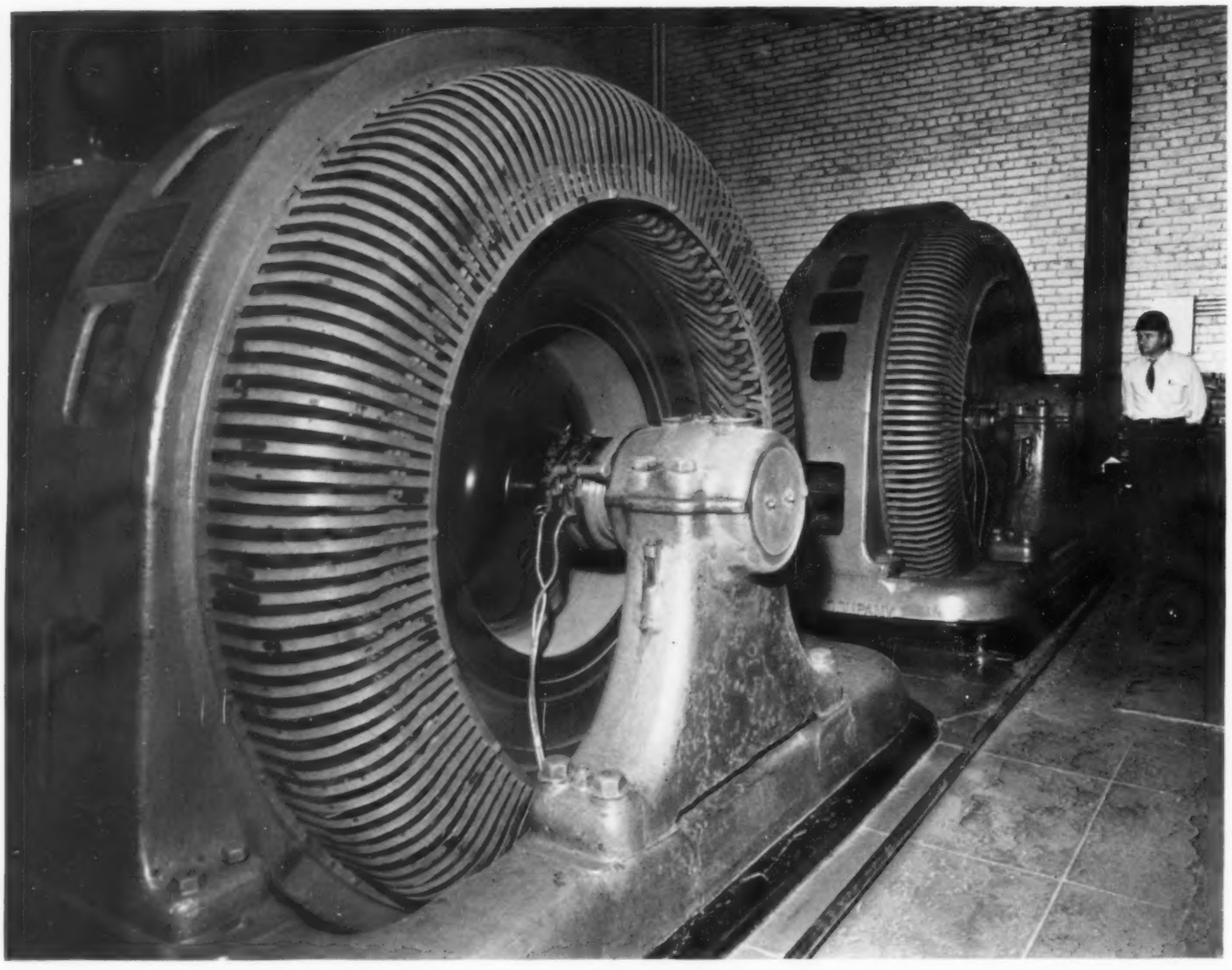
On the big, tough jobs—where dependability *must* be proved—Morgan does the proving again and again. This is why a "Morgan" brings the most efficient and economical results, and why a very high percentage of orders for Morgan cranes are *repeat orders.*

When cranes are a part of your expansion or modernization plans—be sure you plan to talk with the people at Morgan Engineering.



THE
MORGAN
ENGINEERING CO. *Alliance, Ohio*

Overhead electric traveling cranes, gantry cranes, open hearth special cranes, blooming mills, structural mills, shears, saws, auxiliary equipment and welded fabrications.



NATIONAL serves Weirton Steel Company with replacement windings for large motors and generators

These two 2100 HP, 6600 volt synchronous motors drive 1500 KW, 250 volt generators in the Blooming Mill Substation at the Weirton Steel Company, a division of National Steel Corporation. Both were rewound in 1941 with National coils—windings which have now passed 17 years of continuous service. This job is typical of many which National has done over the years for Weirton and other leading steel producers.

National has the engineering "know-how" and experience and the production manpower and facilities to handle rewinding of your biggest rotating electrical machines. National quality is proved by the performance of National windings . . . like these at Weirton which are still going strong after 17 years of service.

For specific recommendations on how National's engineering and manufacturing ability can best be utilized in your electrical maintenance operations, just call your nearby National field engineer or drop us a line.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

TRADE MARK

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

HOT METAL
ON 20 WHEELS!

another first by POLLOCK

THIS particular 20-wheel Pollock Hot Metal Car was built to meet the specific requirements of an eastern steel works plant layout. Pollock engineers designed this car with sufficiently reduced wheel loadings so as to transport 150 tons (an increase of more than 75 tons) across an existing old bridge with sharp curved approaches.

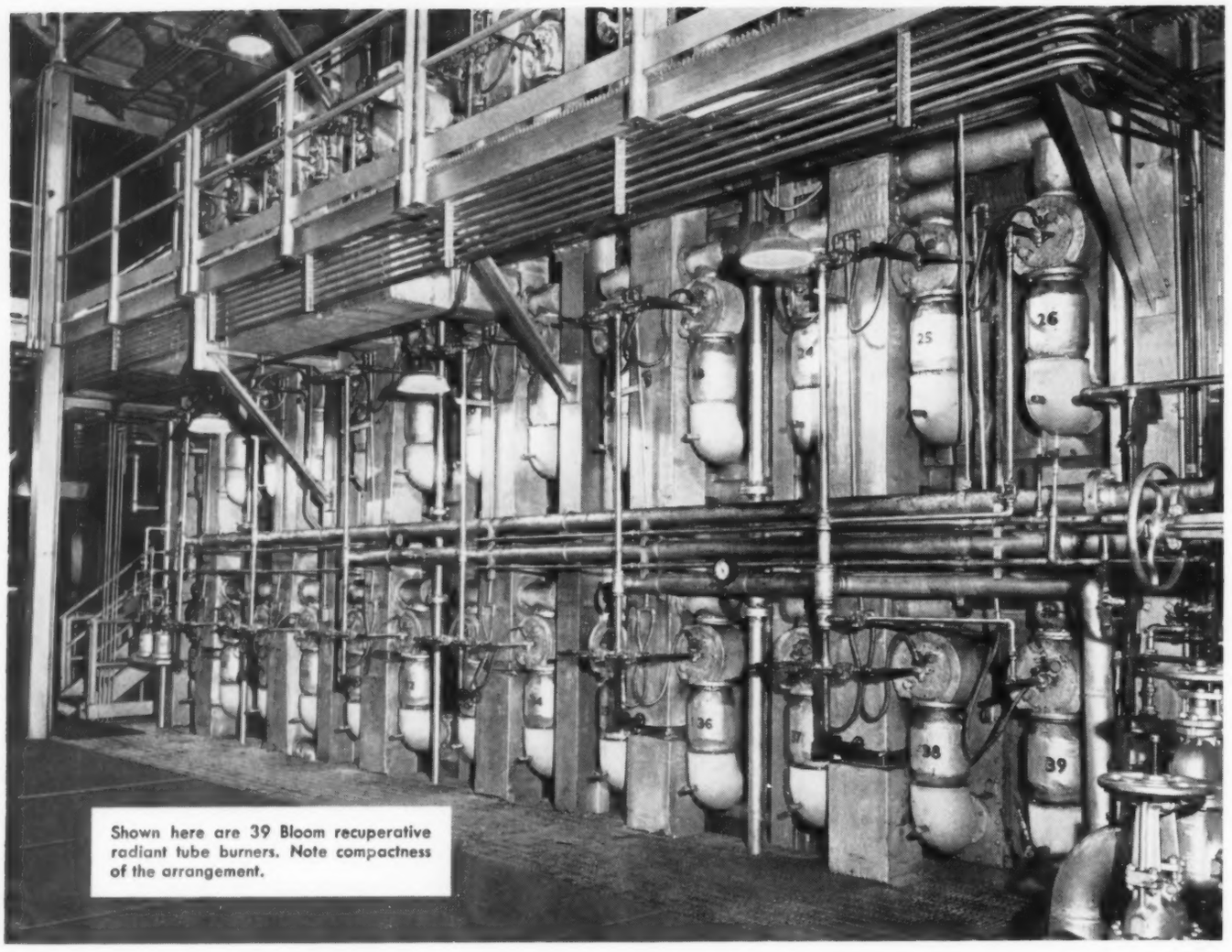
Lower operating costs start from the ground up. Pollock is singularly equipped to deal with all phases of hot metal car engineering and construction. The skill and knowledge of Pollock engineers as related to actual steel mill operating conditions are the keys to Pollock efficiency of operation.

Investigate this newest of hot metal cars . . . call Pollock today.

POLLOCK
SINCE 1863

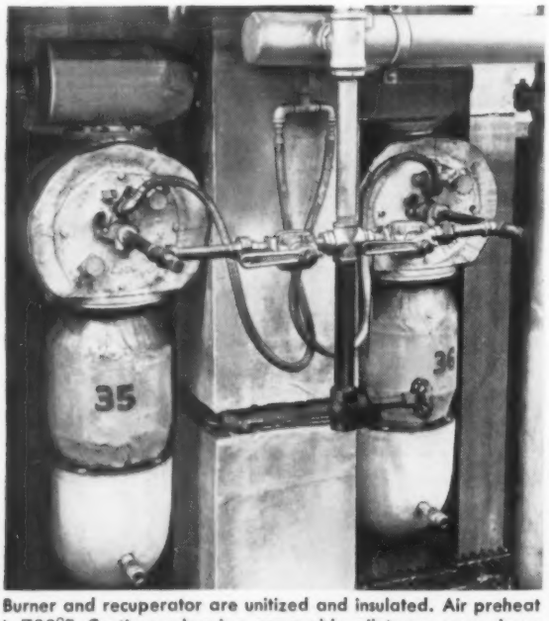
THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN, OHIO
Associated in Great Britain with Ashmore, Benson, Pease & Co.

ENGINEERS, FABRICATORS AND ERECTORS OF BLAST FURNACE STEEL WORK
. . . HOT METAL AND SLAG HANDLING EQUIPMENT FOR . . .
BLAST FURNACE, OPEN HEARTH AND ELECTRIC FURNACE PLANTS



Shown here are 39 Bloom recuperative radiant tube burners. Note compactness of the arrangement.

208 BLOOM BURNERS heat Weirton's giant furnace

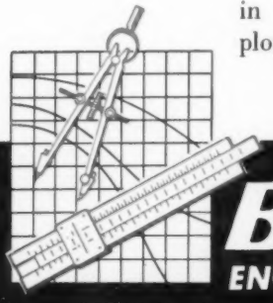


Burner and recuperator are unitized and insulated. Air preheat is 700°F. Continuous-burning, removable pilots are seen above the gas inlets.

Heat to anneal tinplate in the new continuous furnace at Weirton Steel Company is furnished by 208 Bloom Recuperative Radiant Tube burners. The Bloom burners have operated trouble-free for more than a year under severe fuel conditions.

Bloom Radiant Tube burners are designed for operation with coke oven gas, natural gas, butane or oil. Easily-lighted, stable pilots are provided. Alloy construction prevents warping. Proven burner design provides uniformly-heated, clean radiant tubes, thus assuring maximum tube life.

Bloom engineers will gladly cooperate in designing combustion systems employing these or other Bloom burners.



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

THE OXIDATION MECHANISM In The Open Hearth Furnace

by A. L. Hodge,
Staff Engineer (Metallurgy),
Development Laboratory,
Linde Co.,
Division of Union Carbide Corp.
Newark, N. J.

Maximum open hearth production rates require a maximum amount of high temperature heat in excess of bath temperature and maximum availability of chemical oxygen . . . . slow and average furnaces can obtain benefits by oxygen for combustion and decarburization, whereas sharp furnaces are better able to take advantage of ore as a relatively inexpensive source of iron combined with oxygen.

THE production of open hearth steel is essentially a process of high temperature oxidation. Therefore, production rates will depend largely on two factors: (1) supplying high temperature heat to the charge, and (2) supplying chemical oxygen to the melt.

Both factors require explanation. Accordingly, *high temperature heat* includes only the heat available at a temperature in excess of the bath temperature. As an example, let us assume a bath temperature of 3000 F and a flame temperature of 3300 F. In this case, the only heat available to the bath directly is that portion of heat between the temperatures of 3000 and 3300 F.

Chemical oxygen may be defined as that oxygen which reacts with the elements silicon, phosphorous, manganese, carbon and iron, and excludes oxygen for combustion. The source of this oxygen may be ore, sinter, limestone, atmospheric or manufactured oxygen. To produce one ton of steel (50 per cent hot metal practice) ordinarily requires about 3,250,000 Btu of heat and about 1100 lb of total oxygen. This amount of oxygen consists of about 1000 lb for burning all the fuel and carbon monoxide above the bath, and 100 lb for chemical reactions with the metal.

Much has been written on combustion, heat transfer and the use of oxygen enrichment in the open hearth. Accordingly, this paper will deal only with the mechanism and theory of oxidation—particularly of carbon and iron during the refining or working period of the heat. Our ultimate objective is to help provide a further understanding of fundamentals which may suggest ways of improving present steelmaking practice, or to provide an explanation for certain traditional practices.

QUANTITATIVE EFFECTS OF ORE VS OXYGEN ON CARBON REMOVAL

Throughout the earliest history of steelmaking, the chief source of chemical oxygen has been iron oxide in the form of natural ore containing 25 to 30 per cent oxygen by weight. Although the use of ore has several excellent advantages, it also has one outstanding disadvantage—that is, nearly all the chemical and physical reactions between ore and liquid steel are strongly endothermic or heat-absorbing. For example, to react a pound of ore requires about 1200 to 1500 Btu of heat.

In contrast with this undesirable property of ore, it was discovered in the early 1800's that the reaction of air with molten iron to burn out carbon, not only sustained the reaction, but actually provided some excess heat. During the past 10 to 15 years, the use of gaseous oxygen has become almost a universal tool in the open hearth for obtaining high rates of decarbonization and for providing high temperature heat to the bath.

Strict adherence to the concept that steelmaking is a high temperature oxidation process has suggested using large amounts of gaseous oxygen almost throughout the entire heat. As is well known, this is now being done at a number of plants with the use of one or two water-

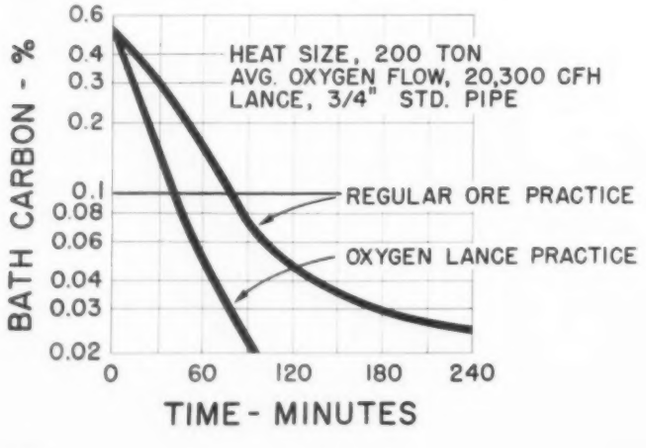
cooled retractable roof lances or jets with oxygen flow rates as high as 80,000 cfhr. This amount of oxygen is equivalent to about 25,000 lb of ore which, if added over the same period, would indeed freeze the average bath. In the production of low carbon steels containing 0.03 to 0.10 per cent carbon, decarbonizing rates with ore and injected oxygen present an interesting comparison.

For example, Figure 1 shows the carbon removal rate curves for a 200-ton heat using ore and oxygen. These curves represent actual data for a relatively large number of heats, with the exception of that portion of the carbon-time curve for oxygen above 0.30 per cent carbon. Above this carbon content, it was not normal practice to begin blowing the heat with oxygen. Therefore, enough heats were lanced in the range of 0.30 to 0.50 per cent carbon to show a straight line relationship on semi-logarithmic paper from 0.50 down to 0.10 per cent carbon. Several interesting comparisons can be made from this illustration. For example, to decarbonize a heat from 0.20 to 0.08 per cent carbon (12 points) required about 40 minutes with ore and 22 minutes with oxygen. A difference of 18 minutes was saved by using oxygen. However, to decarbonize a heat from 0.15 to 0.03 per cent carbon (12 points) required about 115 minutes with ore and about 47 minutes with oxygen or a time saving of 68 minutes. With present "Cost Above" figures of $2 to $3 per minute of furnace time, these savings are significant. Another feature to note about this illustration is the use of semi-logarithmic paper which is ideal for this plot, since it provides excellent representation of decarbonization rates whether varying from 0.50 to 0.20 per cent or from 0.05 to 0.02 per cent carbon.

CAUSES OF VARIATION IN CARBON REMOVAL RATE

An important question arises at this point: Why do the carbon removal rates vary so widely between the use of ore and oxygen and at different carbon levels? A complete answer to this question is relatively complex but can be stated briefly in two parts. First, heat absorbed by ore additions limits the amount of ore which can be added to the bath while the only limitation for oxygen injection is the amount of slag and metal splashing on the furnace refractories. Second, a unique chemical relationship exists between (1) the carbon content of the metal, (2) iron oxide in the slag, and (3)

Figure 1 — Time required is less when decarbonizing with ore than with oxygen.



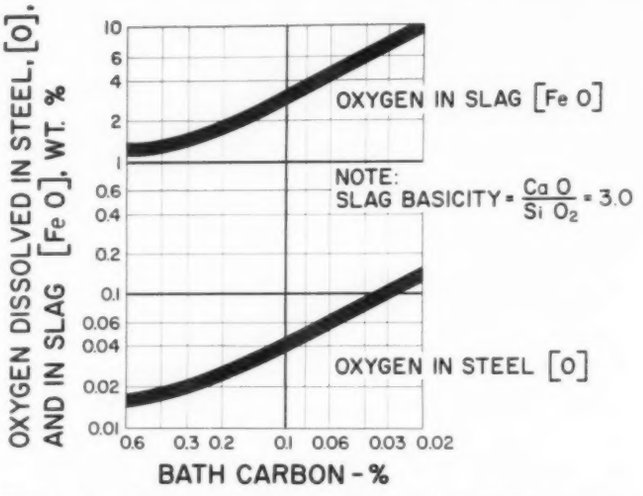


Figure 2 — Oxygen dissolved in the bath and oxygen content (FeO) of the slag goes up as carbon concentration is lowered under average open hearth conditions.

dissolved oxygen in the metal. To obtain rapid decarbonization rates, it is not only necessary to supply oxygen for the carbon reaction, but also to maintain the steel and slag saturated with oxygen.

This relationship is shown in Figure 2. Here, the oxygen of the slag and bath are plotted against carbon content. It should be pointed out that these relationships do not represent what are normally considered as equilibrium conditions; they represent conditions normally present in an open hearth during decarbonization. Hence, the oxygen contents shown are significantly greater. For example, at 0.10 per cent carbon, the equilibrium oxygen content dissolved in steel amounts to about 0.025 per cent instead of 0.042 per cent as shown. The difference of 0.017 per cent between these values can be considered as the "driving force" of the carbon-oxygen reaction. In earlier work by Larsen and Brower, this difference was called the "delta oxygen." In this and subsequent illustrations where slag conditions are pertinent, slag basicity is defined as the simple lime-silica weight ratio. It equals 3.0 with slag volumes averaging about 170 lb per ton of steel. From this, one outstanding feature should be noted. This is the steadily increasing amount of oxygen going to the slag and bath as the carbon content decreases.

Figure 3 shows an actual distribution of the oxygen requirements in weight per cent plotted against the carbon content. These relationships should explain why the rate of decarbonization decreases with decreasing carbon content. In this respect, there is a rapid decrease in the amount of oxygen available for decarbonization if the oxygen input is constant. At 0.50 per cent carbon, for example, about 95 per cent of the available oxygen reacts with carbon and only five per cent is absorbed by metal and slag. At 0.05 per cent carbon, however, only about 15 per cent of the oxygen is reacting with carbon but 85 per cent of the oxygen is being absorbed by the slag and metal.

Figure 4 shows the previous relationships occurring during the decarbonization period. Actually, this represents an average oxygen rate balance on the furnace while working the heat. As may be seen, the rate of total oxygen distribution in cfm per ton of steel is plotted against the bath carbon. The particular shape of the curves was undoubtedly influenced by the fact that

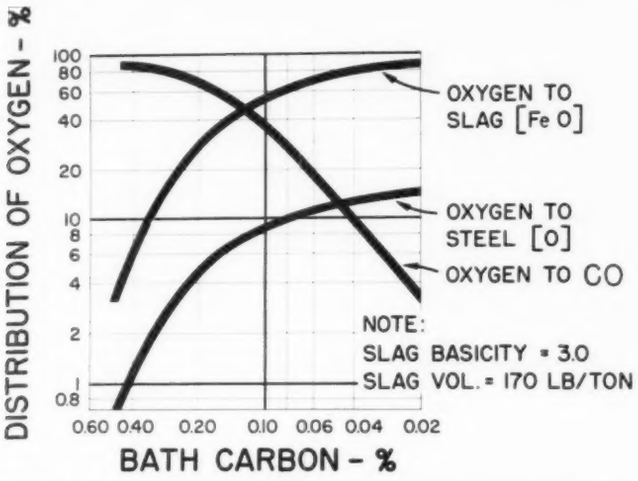


Figure 3 — Theoretical distribution of total oxygen in the open hearth bath versus carbon content during normal decarbonization.

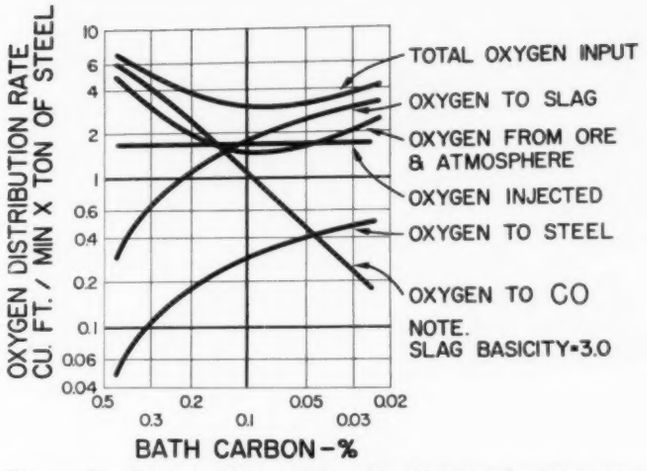


Figure 4 — Curves show oxygen flow balance in the open hearth bath during decarbonization versus bath carbon content.

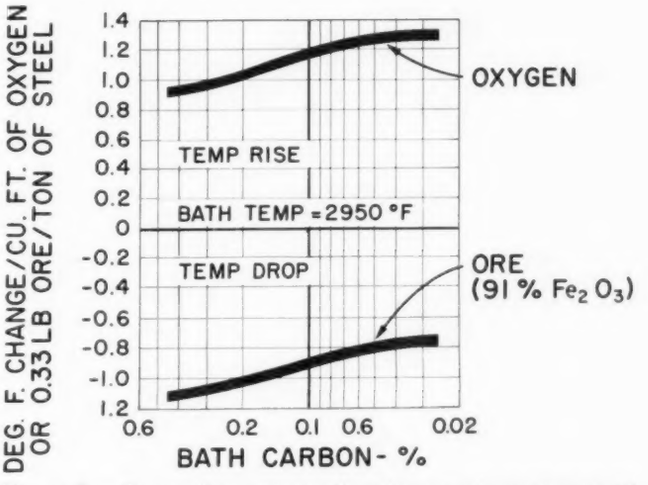


Figure 5 — Curve shows theoretical temperature change of the bath versus carbon content when decarbonizing with ore or oxygen.

about 90 per cent of the heats corresponding to these data tapped between 0.07 and 0.10 per cent carbon and the balance tapped with less than 0.035 per cent carbon. It is interesting to note that the total oxygen available to the bath from ore, atmospheric and injected oxygen, varied between about 6.3 down to 3.2 cfm per ton of steel. In a 200-ton furnace, corresponding rates for an hourly flow basis would be 12,000 times these values or equivalent to about 76,000 and 38,000 cfhr, respectively. The over-all average flow rate of injected oxygen including lance pipe changes and othe interruptions amounted to 20,300 cfhr. It can also be observed that the amount of oxygen reacting with carbon varied from about 6.0 down to 0.2 cfm per ton of steel at carbon contents of 0.45 and 0.03 per cent, respectively. At 0.03 per cent carbon, nearly fourteen times as much oxygen was going to the slag in the form of FeO as was reacting with carbon.

Two suggestions for improving decarbonization practice can be derived from these curves:

1. Increase the total oxygen input from ore and injected oxygen as the carbon decreases to below about 0.10 to 0.12 per cent to maintain a maximum decarbonization rate.

2. Use of minimum slag volume even if requiring a late flush-off, particularly when making steels of 0.06 per cent or less carbon. This would increase the over-all yield of metallics and save on the use of injected oxygen.

THERMAL CHEMISTRY OF ORE AND OXYGEN REACTIONS

Up to this point, it has been shown what happens to the chemical oxygen during oxidation of the bath. But now, we might wonder what corresponding thermal effects are involved with the various main chemical reactions particularly when comparing ore with oxygen. In this respect, Equations 1 and 2 in Table I show the reaction of carbon dissolved in iron with ore and gaseous oxygen. The amount of heat liberated or absorbed at 2950 F is based on one cubic foot of oxygen or its equivalent of about $1\frac{1}{3}$ lb of ore. These reactions show a significant difference in their thermal effect. For example, oxygen liberates about 326 Btu, while the equivalent in ore absorbs 411 Btu. Expressed another way, these heat quantities represent a theoretical increase in bath temperature of 0.9 degree F for oxygen and a decrease of 1.1 F for ore on a per ton of steel basis.

Equations 3 and 4 show the thermal comparison of oxygen and ore when reacting to form FeO, which is absorbed by the slag. In these reactions, oxygen liberates 516 Btu and ore absorbs 223 Btu. The corresponding temperature effects are 1.4 F increase for oxygen and 0.6 F decrease for ore per ton of steel.

Equations 5 and 6 show the thermal comparison for the reaction of oxygen being drawn into solution with iron.

Equations 7 and 8 show the thermal comparison for the reaction of silicon in iron with oxygen and ore. This reaction is practically nil during decarbonization. However, it was included because of the recent high interest for using oxygen in roof jets shortly after making the hot metal addition at which time the oxidation of silicon is important.

In discussing the primary chemical oxidation reactions taking place during decarbonization—that is, those involving carbon reaction, oxygen to slag, and oxygen to metal—it was shown that the extent of these reactions varies essentially with carbon content. It was also shown that different quantities of heat were exchanged for

TABLE I

Comparison of Thermochemical Reactions of Oxidation and Heat Change Above 2950 F When Reacting Ore or Oxygen

Carbon oxidation		
With oxygen	$C_{(in\ Fe)} + \frac{1}{2}O_{2(70\ F)} = CO_{(2950\ F)}$	(1)
	Heat liberated = 326 Btu per cu ft O_2	
	Temperature change = + 0.9 F per ton of steel	
With ore	$3C_{(in\ Fe)} + Fe_2O_{3(70\ F)} = 2Fe + 3CO_{(2950\ F)}$	(2)
	Heat absorbed = 411 Btu per 0.33 lb ore	
	Temperature change = 1.1 F per ton of steel	
Iron oxidation to slag		
With oxygen	$Fe + \frac{1}{2}O_{2(70\ F)} = FeO_{(slag\ at\ 2950\ F)}$	(3)
	Heat liberated = 516 Btu per cu ft O_2	
	Temperature change = +1.4 F per ton of steel	
With ore	$Fe + Fe_2O_{3(70\ F)} = 3FeO_{(slag)}$	(4)
	Heat absorbed = 223 Btu per 0.33 lb ore	
	Temperature change = 0.6 F per ton of steel	
Oxygen to solution with iron		
With oxygen	$\frac{1}{2}O_{2(70\ F)} = (O)_{(in\ Fe\ at\ 2950\ F)}$	(5)
	Heat liberated = 247 Btu per cu ft O_2	
	Temperature change = +0.7 F per ton of steel	
With ore	$Fe_2O_{3(70\ F)} = 2Fe + 3(O)_{(in\ Fe\ at\ 2950\ F)}$	(6)
	Heat absorbed = 490 Btu per 0.33 lb ore	
	Temperature change = 1.4 F per ton of steel	
Silicon oxidation		
With oxygen	$Si_{(in\ Fe)} + O_{2(70\ F)} = SiO_{2(2950\ F)}$	(7)
	Heat liberated = 928 Btu per cu ft O_2	
	Temperature change = + 2.6 F per ton of steel	
With ore	$3Si_{(in\ Fe)} + 2Fe_2O_{3(70\ F)} = 4Fe + 3SiO_{2(2950\ F)}$	(8)
	Heat liberated = 238 Btu per 0.33 lb ore	
	Temperature change = +0.7 F per ton of steel	

each reaction. Taking these variations into account permitted calculating the change in temperature of the bath at different carbon contents as shown in Figure 5 when using oxygen or ore or any combination of these oxidizing compounds.

This illustration shows the thermal effect of decarbonization on the bath plotted against the carbon content. Although these are theoretical values, in actual open hearth tests, however, actual measurements were fairly close to those shown by the curves. From this plot, an oxygen injection rate of 30,000 cfhr in a 200-ton furnace at 0.10 per cent carbon would be expected to increase the bath temperature about 3 F per minute. A similar decarbonization rate with ore would require an average ore feeding rate of about 10,000 lb per hr, and the bath temperature would be expected to decrease about 2 F per minute. Of course, these temperature changes do not take into account the effect of firing practice or bath action. They do, however, indicate means for improving bath temperature control. When the bath is hot, for example, advantage can be taken of the extra metallics available by using ore for oxidation. On the other hand, when the bath is inactive and needs heat, oxygen injection is the best choice.

SUMMARY

1. The mechanism of oxidation in the open hearth is relatively complex but can be expressed by three primary chemical reactions occurring simultaneously. The extent to which each reaction proceeds will depend mainly on the carbon content of the bath and each will exert a different thermal effect.

2. All ore reactions with steel and with slag during decarbonization are endothermic (require heat). Corresponding reactions with gaseous oxygen are exothermic and liberate heat.

3. Maximum open hearth production rates require (1) a maximum amount of high temperature heat in excess of the bath temperature, and (2) maximum availability of chemical oxygen to maintain high rates of oxidation.

4. Sharp working furnaces can process ore rapidly and efficiently. It is thus possible to take advantage of a relatively inexpensive source of iron combined with oxygen.

5. Normally slow or average furnaces can obtain significant benefits by using oxygen for combustion and decarbonization.

6. A large amount of oxygen and iron is lost to the slag at carbon contents below about 0.08 per cent. These losses may be materially decreased by carrying minimum slag volumes and by maintaining active bath action. ▲

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Automatic Numerical Data Logging and Processing in the steel industry

. . . . data processing has almost unlimited possibilities and the steel industry is just starting to make use of such systems . . . . its use will aid more efficient production . . . . initial applications are on tinning lines . . . .

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TO many people the term "data processing" conjures up images of digital computers or other business machines so increasingly common in accounting offices. To others it may symbolize automatic typewriters droning away logging temperatures or pressures in an oil refinery or chemical plant. Actually, the term "data processing" as we use it here does include these things, which happen to be among the earlier applications of this new field in industry. But what have these strange devices to do with making steel? Of what use are they to a mill superintendent in his every day production problems?

Before describing some specific equipment and applications we would like to outline briefly how data logging and processing fit into the more completely automated processes we will see in the future.

THE STEEL PLANT PROCESS OF THE FUTURE

What do we mean by a completely automated process? Although this will of course vary with the process, one general definition might be that it is a system which includes these four elements, properly integrated: Regulating, programming, data logging and computing.

We are all familiar with regulators, and most processes have one or more of them. Their basic purpose is to monitor one variable and maintain it at a desired value (Figure 1). This value, the reference, is normally selected by the operator setting a rheostat or switch. The regulator also speeds up the response of the system.

A more recent development is programming control. Such a control may use punched cards, punched tape or other storage means, even pushbuttons, for defining the program. The selected program is used to instruct the regulating system to follow a predetermined pattern. In other words, the program control now sets the reference which was set manually in the simple regulating system. In the preset screw-down control, for example, a punched card supplies the desired roll opening programming to the screw-down regulating system.

The third system element in our automated process is data recording (Figure 2). This is important to our completely automated process for several reasons. It is the eyes and ears of the process, so to speak. It observes and reports back information on the process to aid the operators in making readjustments to obtain optimum quality or output. It also furnishes data

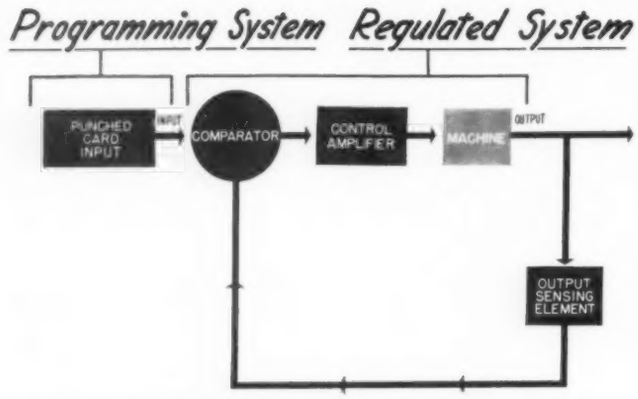


Figure 1 — Block diagram shows process with a regulator and programming control.

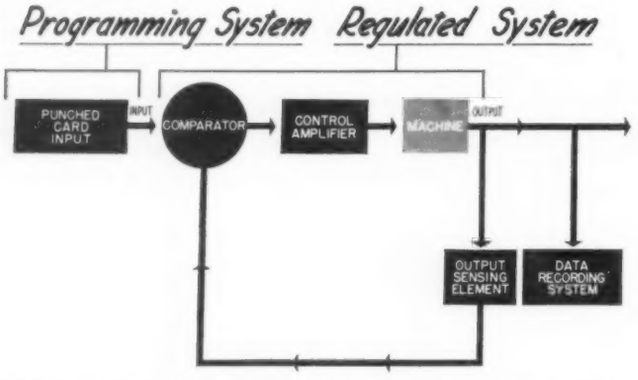


Figure 2 — Block diagram shows process including data recording equipment.

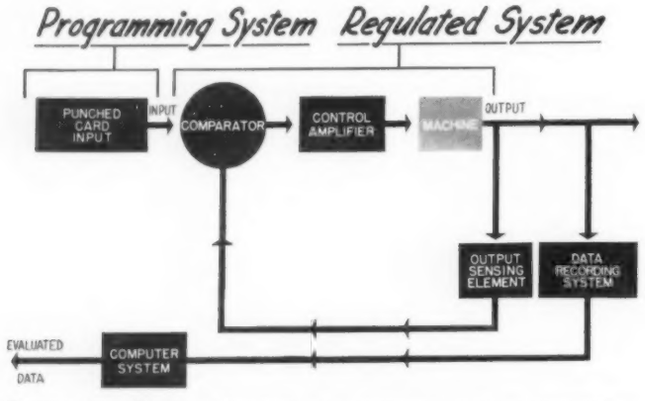
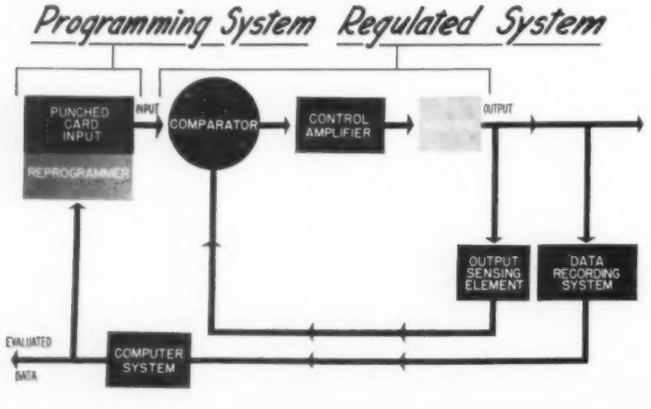


Figure 3 — Block diagram of a process with a computer added to the data logging equipment.

Figure 4 — Block diagram shows process with computer control overriding the programmer and regulator.



necessary for such functions as production control, payroll and quality control. Still further, on a not-yet-automated process, it can supply important knowledge of the significant parameters and their interrelations. This can be an important aid to further automating the process.

The final step in our completely automated process is the addition of a computer to the other three elements (Figure 3). In a simple form the computer might be used as part of the data logging system if some computing is required to evaluate or use the data. In a more advanced form the computer might be used to close a completely automated feedback loop (Figure 4). For example, the computer might examine the process data and reprogram the regulating system to improve the product. This last step has not yet been made in the steel industry, but is certainly on the way.

From the foregoing it can be seen that data logging is a very important element in a completely automated system. However, its use is by no means restricted to such a system. It can produce benefits on many existing processes right now.

WHAT DATA LOGGING CAN DO NOW

If logging of data is important, it must be done in the steel mills today, and of course it is. Two methods are in common use: strip chart recording instruments and periodic manual logging. However, we are talking here about *automatic numerical* data logging, which distinguishes it from either of these methods. Some of the advantages of replacing human data loggers are quite obvious: greater accuracy, higher number of readings taken and simultaneous or near simultaneous readings of a large number of variables. Other gains are not quite so apparent. Manually collected information is rather useless until read and interpreted, a time consuming duplication of effort. Also it often needs to be correlated with data from other parts of the plant before it becomes useful, and this again takes time. Some variables may change too rapidly for manual readings to be of much use.

Strip chart recorders overcome many of the drawbacks of manual data collection, but not all of them. For practical reasons chart speeds are usually so slow as to make these records of little use in analyzing troubles that often involve rapid changes. Correlation in time of charts from different recorders is not easy. Charts have to be read with an experienced eye, and the mere fact that they have to be read and transcribed before the data can be used later in the process may make them little if any more useful than manual logging.

In addition to its higher speed and larger capacity, perhaps one of the most significant advantages of automatic data logging equipment is its ability to provide the right kind of data, without redundant information, to all plant departments. For example, production, engineering, accounting, payroll, quality control and top management are all interested in different information. An automatic data logging system can provide each of them with just what they need and only what they need. Furthermore, this information can be presented in directly usable forms. These might include punched cards for accounting or

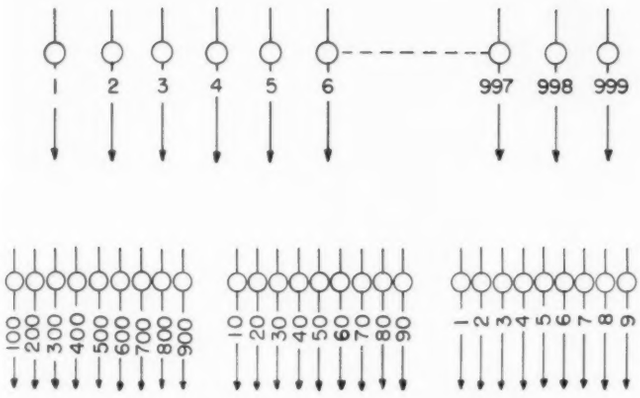


Figure 5 — Top system has no code, bottom system uses decimal code which reduces number of wires.

payroll, and type written reports for production or top management. When desirable, the information will be available immediately, in any part of the mill, or even in distant cities. Still another advantage is that some data which is difficult to obtain by older methods can be automatically logged. An example of this might be feet of off-gage strip in a coil.

DATA PROCESSING TERMINOLOGY

At this point it might be well to define some of the terms we are using. Data of course refers to almost any quantity, such as voltage, speed, temperature, etc. Processing involves doing something with the data. This may include transmitting, logging (or recording), storing for future use, and computing, to name some of the more common functions often included. Two other general terms often seen are data handling, which includes moving or transmitting, and data reduction, which implies changing its form as by computing.

Two other common words are analog and digital, used to specify the form the data takes. An analog signal is one that is continuous and changes smoothly. An analog of speed, for example, would be the voltage from a tachometer generator. A digital (or numerical: we use the two words interchangeably) signal, on the other hand, is discontinuous and changes in discrete steps. It is usually either in the form of pulses, such as in Morse code, or combinations of energized and deenergized wires or contacts, such as obtained with various positions of a drum switch. Although not confined to it, use of the word "data" normally implies a digital system.

With any digital system, the data is represented by a code which, properly interpreted, becomes the desired number. The specific code used will vary from system to system.

Suppose we want to represent some quantity that may vary from 0 to 999. We can do this by having 999 wires, and energizing the one corresponding to the number we want (Figure 5). This appears rather ungainly, to say the least, so we decide to use a code. The most obvious choice would be a decimal code, which we use every day. The assigned value to the wires would then be 1, 2, 3 —, 9; 10, 20, 30 —, 90; 100, 200, 300 —, 900. Any number would be represented by energizing a combination of three wires. This would

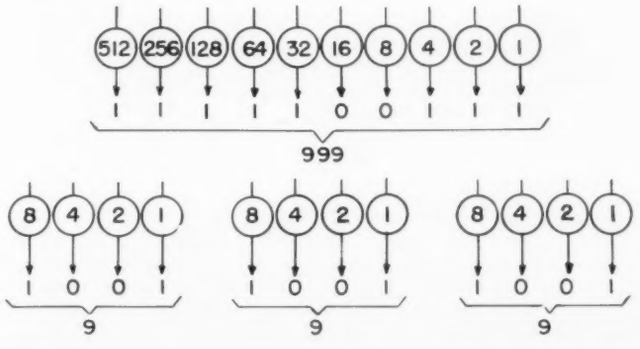
DECIMAL		BINARY				
10	1	16	8	4	2	1
	1	0	0	0	0	1
	2	0	0	0	1	0
	3	0	0	0	1	1
	4	0	0	1	0	0
	5	0	0	1	0	1
	6	0	0	1	1	0
	7	0	0	1	1	1
	8	0	1	0	0	0
	9	0	1	0	0	1
1	0	0	1	0	1	0
1	1	0	1	0	1	1
1	2	0	1	1	0	0
1	3	0	1	1	0	1
1	4	0	1	1	1	0
1	5	0	1	1	1	1
1	6	1	0	0	0	0
1	7	1	0	0	0	1
1	8	1	0	0	1	0
1	9	1	0	0	1	1
2	0	1	0	1	0	0

Figure 6 — Comparison of decimal and binary numbering systems.

require a total of 27 wires, which is a significant reduction. In spite of its compatibility with our senses this code has some disadvantages, and still requires too many wires. Our numbering system itself is of course a decimal code; that is, it is a numbering system with a base of 10. This means that after 10 digits we add a digit one column to the left and start over (Figure 6). It is possible to construct a numbering system with any base. For many reasons, especially because there are many devices which have two stable states, such as the open and closed positions of a relay, a base 2 numbering system is commonly used in digital systems. This is constructed in a similar manner except that after only two digits a digit is added to the column on the left. If this were extended to 999, it would be seen that there would be 10 columns, requiring only 10 wires to represent any number from 0 to 999 (actually $2^{10}-1$ or 1023). The two digits are 0 and 1, where 0 usually is represented by a deenergized wire or open contact, while a 1 is represented by an energized wire or closed contact.

Although the binary code is fine for a lot of work,

Figure 7 — Top shows binary code system. Bottom shows binary decimal code.



it is still desirable to read out in the familiar decimal code. A compromise code, called "binary-coded decimal" or simply "binary-decimal" has been evolved as a code that combines the advantages of both systems. In this code a number is represented in decimal form, but each decimal digit is represented in binary code, using only the first ten digits of that code (Figure 7). Since ten digits can be represented by four columns or wires, a total of 12 wires is required, only two more than for straight binary for the example chosen. The ease of conversion from or to decimal code has made the binary-decimal code or modifications of it very practical for data logging systems. For some specific applications, such as controlling electric typewriters or card punches where letters and numbers are handled, additional wires or bits are sometimes used ("bit" is used in digital language to represent the smallest unit of information, corresponding to a binary digit). Many other variations are used where their peculiar characteristics provide some advantage in increasing reliability or simplifying the circuitry.

COMPONENTS USE IN DATA PROCESSING

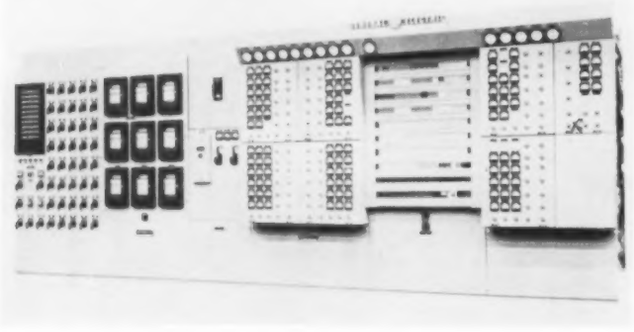
One of the striking aspects of data processing is the components used. Perhaps not surprisingly, they are for the most part completely different devices than found in presently installed steel mill controls. It should be recognized, however, that changes in appearance are not confined to data processing equipment. The advent of static switching devices, for example, has created a new look in conventional reversing blooming and slabbing mill control (Figure 8).

Data processing equipment requires many functions that are not usually performed by conventional steel mill controls. For these functions, a great many devices have been developed. Many of these do not yet have the reliability, ruggedness and long life under adverse environment that is required of steel mill control, but great efforts are being expended in this direction. At the present time it appears that semi-conductor and magnetic devices hold the most promise.

ANALOG-DIGITAL CONVERTERS

Since practically all of the data with which we work is measured by sensing elements producing analog signals, the first device required by any digital system is an analog-to-digital converter. These fall into two main categories; shaft position-to-digital and voltage-to-digital. Although very little data actually exists in the form of a shaft position, almost any variable can be converted to a proportional shaft position through use of a servo amplifier or self-balancing instrument (the familiar strip chart recorders used with thermocouples are almost all of this type). The shaft converter may then be driven by the servo motor to produce the digital equivalent of the measured variable.

Figure 8 — This modern slabbing mill main control panel utilizes static switching.



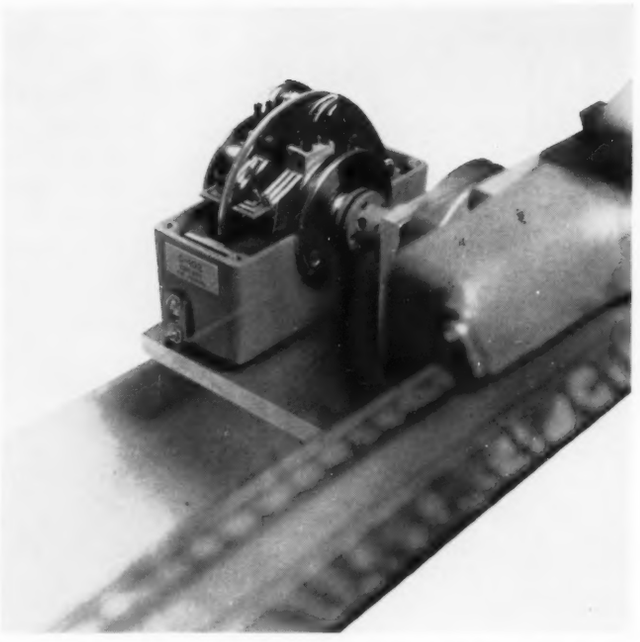


Figure 9 — An example of a shaft encoder or shaft position-to-digital converter.

There are probably more shaft converters on the market than any other component of data processing systems, and their construction varies greatly. The familiar drum switch could be considered a form of shaft converter, and performs a similar function. This is to provide a unique contact combination, or code, for each of a number of shaft positions. The differences are largely of degree. Shaft converters usually provide 100 or more codes for each revolution, may make 10 or more revolutions before repeating, and usually are coded in one of the many binary codes, such as binary-decimal already described. They may make use of cam operated contacts, commutators and brushes, translucent and opaque segments on a disk, or other means (Figure 9).

Shaft converters have become very popular and numerous for several reasons. They are relatively small, simple, inexpensive devices, and many of them can easily be installed in self-balancing type recording instruments. Since a lot of data logging equipment may be installed where recording instruments already exist, this provides the simplest method of digitizing the variables.

A somewhat special form of shaft digitizer which finds many uses in steel mills is the pulse tachometer. Rather than converting shaft position to a special code, it simply produces a predetermined number of pulses for each revolution. These can be used to count revolutions or feet directly, or can be used with timing devices to measure speed. Pulse tachometers may use photoelectric tubes, magnetic pickups, proximity switches or other means to produce pulses.

The other broad category of analog-digital converter, or digitizer, is the direct voltage-to-digital type. The digital voltmeters that have recently appeared in large numbers are a common form of this type of digital converter (Figure 10). These converters are often all-electronic using vacuum tubes or transistor components with no moving parts. As a result they are often capable of making several thousand conversions per second as compared to about one per second for the shaft digitizer-recorder combination. The voltage-to-digital converter is a more expensive converter, but by multiplexing or time sharing, one converter can be rapidly switched between several channels, thus doing the work of many units.

OTHER INPUT DEVICES

In addition to the analog variables being logged, most data systems have other inputs that are to be read out with the process data. These include such information as date and time, material specifications, information for production and accounting records, etc. Such information can be read into the system via operator controlled pushbuttons or selector switches. That part of the data that can be prepared ahead of time, particularly when it is more or less repetitive in nature, can often be inserted by means of punched cards or tape.

Tape readers are simpler, usually more reliable and considerably less expensive than card readers. Partly for these reasons they are finding great favor in the machine tool industry for programming machines, particularly in applications which allow the same tape to be read repeatedly. Some of the disadvantages of tape are that it is inconvenient to handle in short lengths and difficult to rearrange data or sort it when in longer lengths.

Punched cards, which are becoming popular input means in the steel industry, have several advantages. They are especially convenient when processing ingots or coils or other batch units, but probably the chief factor encouraging their use is the ability to punch, read, sort and process them on standard business machines usually available. In our opinion the chief disadvantage of using punched cards is the complexity of available card readers.

STORAGE DEVICES

One of the basic and common functions performed by almost any digital equipment is that of storage. This is particularly true of computers, but even data loggers usually require storage in one form or another. For example, storage is necessary with many card readers, either because the reader puts out only pulses or reads the card faster than the system can act on the information. Actually the punched card itself is a storage device, so this operation is really transferring from one storage to another.

Counting is another common storage situation. Here the storage problem is simply that of remembering the total counts received up to any given time.

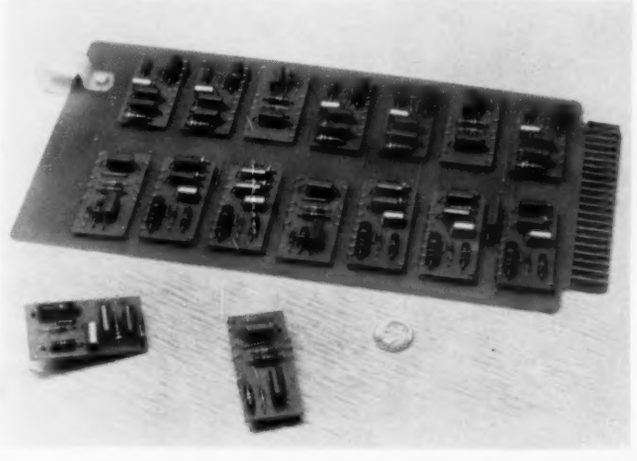
Since, as we have mentioned, digital systems usually operate in a binary code, each unit of storage has only

Figure 10 — The digital voltmeter is one type of analog-to-digital converter.

two states to remember. Thus a relay is one of the simplest and most common storage elements. De-energized it can be said to represent a "0," and energized a "1." The electronic equivalent of the relay is a tube or transistor "flip-flop." This is a circuit utilizing two tubes or transistors and arranged so that one or the other tube or transistor is "on" or conducting depending on the type or sequence of the input, usually a pulse. These basic units, which may be standardized and made in printed circuit form (Figure 11) are the basis of most electronic counters and much of the logic and computational circuitry in static data processing systems and computers.

Two other basic storage devices often used in this work are magnetic drums and magnetic cores. Both

Figure 11 — This electronic counter utilizes transistors and printed circuits. One of the small cards is one-half of a transistorized "flip-flop."



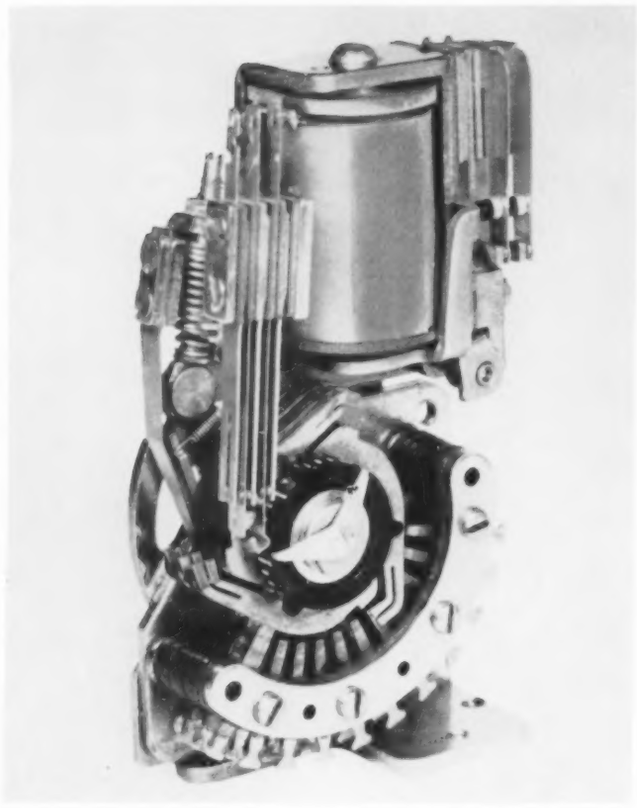


Figure 12 — This typical stepping switch is used for scanning and programming.

of these devices depend on the ability of certain magnetic materials to retain an extremely large degree of residual magnetism when saturated in either direction. Gating or switching circuits are necessary for these devices to locate the proper storage element and determine the direction of magnetization. This can then be interpreted as a "0" or "1" as desired.

Even punched tape may be used as storage, and an example of its use as temporary storage will be described. Because the only fundamental requirement is that the storage medium be "bi-stable," there are an almost limitless number of possible storage schemes. Most of the new ones are being developed because of increasing requirements for more storage capacity in less space, such as in air-borne or very large computers.

Figure 13 — Automatic typewriter includes a paper tape punch and an edge-punched card reader.

SCANNERS

Another common function of data processing equipment, and especially of data logging, is the scanning of many quantities. Basically this involves connecting one circuit in some predetermined sequence to a number of other circuits. For example, in reading a punched card or tape, each digit must go to a different storage unit or other function, so a scanner is used. These may also be called "programmers," in which case their function is similar but may include directing the sequence of several scanners as well as other operations.

Although unpopular with many people, the work horse in this field is the stepping switch (Figure 12) of dial telephone fame (although it is being replaced by the crossbar switch and even by electronic switching in new exchanges). Although many people have had trouble with stepping switches, many others believe they will give long and satisfactory service when properly applied and maintained. In spite of controversy over them, they continue to find wide usage simply because there is no other device currently available that performs their functions as simply and inexpensively.

For higher speed scanning, or simply to avoid using stepping switches, there are other means available. One is the mercury jet switch, in which the movable contact is a thin stream of mercury. Completely static scanning is also performed, either by means of static switching units or by electronic circuits. For high-speed electronic data processors one of these methods may be necessary if the scanning speed is not to limit the speed of operation of the equipment.

OUTPUT DEVICES

For data logging especially, the output device is particularly important, since it produces the end product of the system. The device almost always used is the automatic electric typwriter (Figure 13), which is basically the same machine long used in teletype service. One important limitation of the typewriter is its maximum speed of about ten characters per second. If it is necessary to take data at rates faster than this

Figure 14 — Production report is produced by the tandem mill data logging system.

GAGE NO.1 SETTING	TENSION LIMIT DEVIATION TOL.	GAGE NO.4 SETTING	COMPOSITION	COIL IDENTIFICATION	ROLLER TURN	DATE TIME	ON GAGE LENGTH (BLACK)	OFF GAGE LENGTH (RED)	TOTAL LENGTH	FINISH TIME	WEIGHT
xxx	x	xxx	xx	xxx xxx xxx xxx	x	xxxxxx	xxx xxx		xxx	xxx	xxx
xxx	x	xxx	xx	xxx xxx xxx xxx	x	xxxxxx	xxx xxx xxx xxx		xxx	xxx	xxx
xxx	x	xxx	xx	xxx xxx xxx xxx	x	xxxxxx	xxx xxx				
(DELAY TIME)	(DELAY REASON)			(END DELAY TIME)			xxx xxx		xxx	xxx	xxx
xxx	x	xxx	xx	xxx xxx xxx xxx	x	xxxxxx	xxx xxx		xxx	xxx	xxx

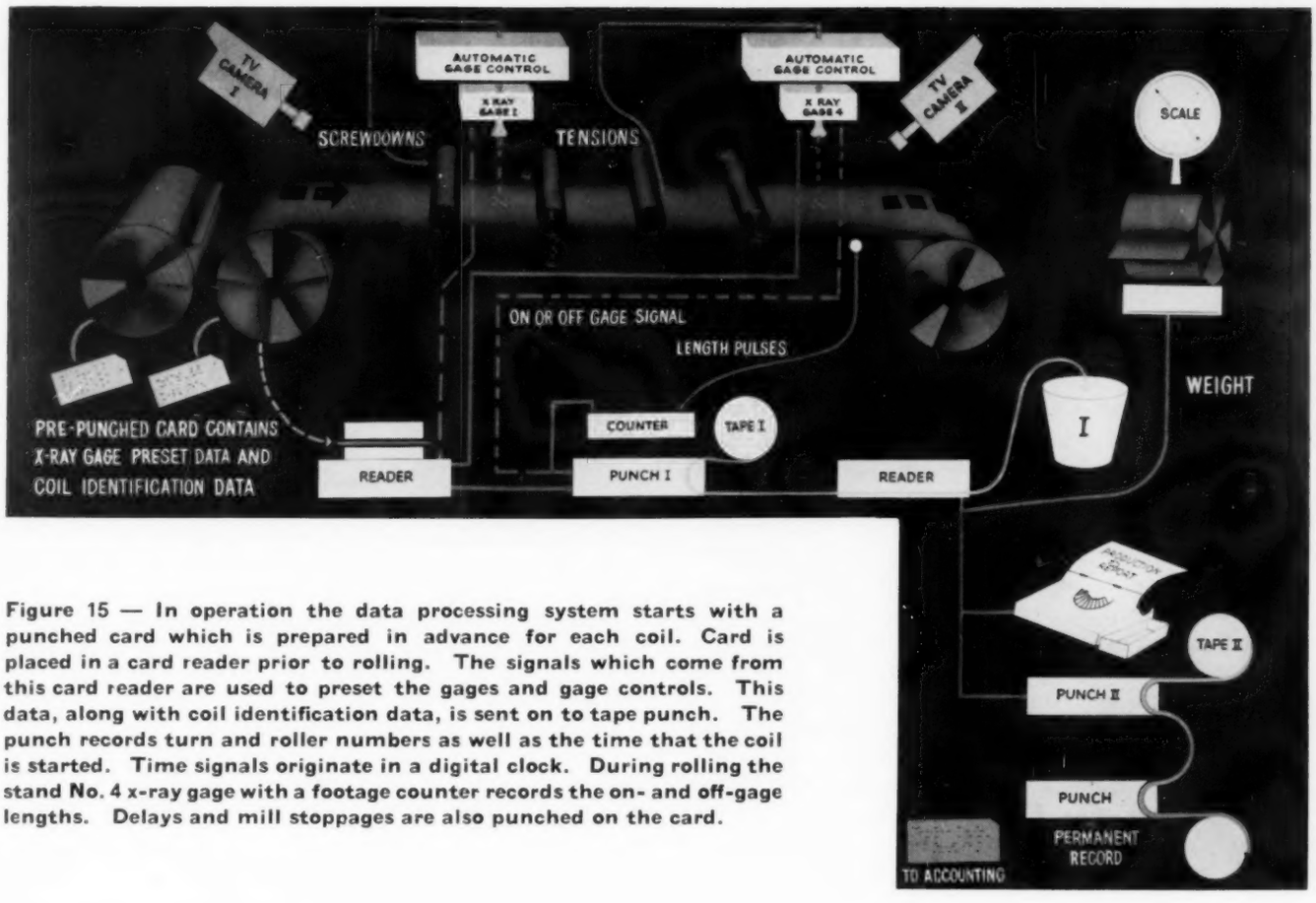


Figure 15 — In operation the data processing system starts with a punched card which is prepared in advance for each coil. Card is placed in a card reader prior to rolling. The signals which come from this card reader are used to preset the gages and gage controls. This data, along with coil identification data, is sent on to tape punch. The punch records turn and roller numbers as well as the time that the coil is started. Time signals originate in a digital clock. During rolling the stand No. 4 x-ray gage with a footage counter records the on- and off-gage lengths. Delays and mill stoppages are also punched on the card.

it must either be fed into a buffer storage first or a higher speed printer must be used. Specialized printers with top speeds several times that of a typewriter have been built, but the typewriter, with or without buffer storage, is presently the most popular read-out device.

Although the typewriter produces readable or "hard" copy, desirable for production reports and the like, its output is not of much use for further processing. If for maximum benefit from data logging equipment, further processing is necessary, as is often the case, other output devices must be used. Also, since the typewriter is a rather complex mechanism, and hence subject to more breakdowns than simpler devices, it is wise to provide a second output device in parallel with the typewriter.

For these purposes paper tape punches and card punches are often used. Paper tape is particularly useful as it provides a compact form of permanent storage, from which duplicate hard copies can be made at any time. The tape can also be used to control computing equipment or other processes, or to produce punched cards containing part or all of the data. Since the tape is in effect infinitely long there is no space problem as with punched cards.

Punched cards can also be produced directly from the data system output, and have all of the advantages cited for them as input means.

For high-speed systems magnetic tape is used. Whenever a recording speed greater than about 60 characters per second is required, magnetic tape might be considered as an alternate to using an intermediate buffer storage, or might be used as the buffer storage itself.

TANDEM COLD STRIP MILL DATA PROCESSING SYSTEM

What is believed to be one of the first programming and data logging systems to be applied to a rolling mill has recently been installed on a four-stand tandem cold mill. In the brief description which follows, most of the functions already mentioned will be recognized, plus one or two others. First, let us look at the benefits to be obtained through the use of such equipment.

In practically all cases two x-ray gages and a complete automatic gage control system will be used on the mill. Although the gage control system relieves the operators of some direct responsibility for controlling strip thickness, it does add several adjustments to be made during any schedule change, and of course provides opportunity for operator errors. Thus the first function of the system is to program or preset the x-ray gages and control automatically from a punched card.

The second function of the system is to automatically prepare a production report (Figure 14). Since up to 100 coils may be rolled in one turn, the paper work in preparing this manually can be quite extensive and offers opportunity for operator errors. Not the least of the advantages of the automatically prepared report is that it is typed while the coils are being rolled and thus is always available and current.

One of the features which cannot be included under

the old system is a record of lengths along the strip when thickness goes in or out of tolerance. This is quality control information, serving as a check on the automatic gage control and the mill operators, but also usable to determine the subsequent disposition of the coil or even to control shearing in a later operation.

A final function of this system is that it produces punched cards which can be used to automatically compute operators' pay.

Figure 15 shows schematically how this data processing system operates. A punched card, prepared in advance for each coil, is placed in the card reader by an operator prior to rolling each coil. Signals from the card reader are used to preset the gages and gage controls. This data, together with coil identification data is sent on to the tape punch. The tape punch also records the turn and roller numbers, plus the time the coil is started. Time signals originate in a digital clock.

During rolling, the stand No. 4 X-ray gage, together with a footage counter, records on tape I the "on-gage" and "off-gage" lengths. If there is a delay or mill stoppage, during rolling or between coils, the time the delay started and stopped, together with the reason is also punched in the tape. At the end of the coil the total length and finish time are punched.

The punched tape is now complete except for coil weight, which may not be obtained until after the next coil has started through the mill. Since it is necessary that the weight appear on the record with the other information for the same coil, the delay creates a problem. It was solved in this case by causing tape I to be immediately read and a second tape II punched. The second tape then waits for the coil weight data, and the first tape, which now has served the function of buffer storage, continues to collect data on the next coil. Since the second tape contains complete information on each coil it is preserved, and the first tape is scrapped.

Simultaneously with punching the final tape, an automatic typewriter prints the production report. If the typewriter should be out of service the tape can be put through a tape reader later to type the production report.

To prepare punched cards for payroll, the final tape is fed to a tape-to-card punch, which extracts the information necessary for payroll purposes and prepared cards for later processing in office machines.

This data system is completely divorced from the operation of the mill. One operator is assigned full time to operating the equipment. This permitted inclusion of all components in a single control desk (Figure 16) except for the few that had to be at the mill. This desk is installed in an air-conditioned room a short distance from the mill. A closed circuit TV camera helps keep the operator in touch with what is happening at the mill.

Although space does not permit a detailed description of the design of this equipment, it may be of interest to note that it is an all magnetic relay system. All of the scanning, programming and data distributing functions are handled by stepping switches. The decision to use this design was based in part on the fact that there was no need for high speed operation,

Figure 16 — The operator's control desk for the tandem mill logging system. All components for the system are mounted in the desk.

so that all components could be operated at a fraction of their ratings.

DATA LOGGING SYSTEM FOR ELECTROLYTIC TINNING LINES

Whereas, in the tandem mill example just described, the economic justification for the data processing system may not be completely apparent, automatic data logging in some form is considered almost indispensable by many producers of electrolytic tinplate. This situation has come about by the recent decision of the major can companies to purchase tinplate in coil form, rather than in sheets. This means that the customer, rather than the supplier, will do the shearing and classifying. Present inspection methods also present problems due to the higher line speeds. Because of the obvious need of the producer to know rather precisely such things as the amount of prime strip and the amount of the various defects, without rewinding the strip, a new approach was needed. This is, of course, an area for which numerical data logging is admirably suited.

Figure 17 illustrates in simplified block diagram form the functioning of one such system that is being built. Length signals, in the form of a pulse for each foot of strip, originate in a pulse tachometer driven by an accurately machined wheel riding on the strip. Inspection devices, including strip thickness gage, pinhole detector, matte finish detectors and coating weight gages automatically gage the footage pulses to the proper counters to record the total feet of strip containing each of the defects. Other counters, together with logic or decision-making circuitry, count total feet of "waste-waste," "mender" and "prime strip." The particular combinations of defects that define these categories are, of course, at the option of the user, and can easily be changed.

Because the inspection gages are located at various points on the line, gage operations that occur simultaneously do not refer to the same foot of strip. To correct this situation, the signals from the earlier gages are delayed until the signal corresponding to the same

foot of strip is received from the last gage. This is accomplished with a specialized form of storage device known as a shift register.

Other inputs to the data system are quite similar to those for the tandem mill system described: coil identification, specification data and time, including delay times and reasons, and coil weight.

At the end of a coil, signified by operation of the shear, the data in all of the counters is quickly transferred to a buffer storage. As soon as they are read out, the counters are reset to zero and start counting feet for the next coil. This all happens before a single foot of strip passes so that no counts are lost.

While the next coil is in process, the data on the previous coil is read out to an electric typewriter and a card punch. In the meantime, the coil will be transferred to a scale, and at the proper time the weight will be read out. The complete read-out occurs in less time than it takes to process the next coil so that the buffer storage is ready to accept the new coil.

It can be seen that in method of operation there are many similarities between the tinning line data logging system and the tandem mill system previously described. In construction of the equipment, however, there are many differences. In the tinning line equipment, all logic, counting, buffer storage and shift register functions are performed by transistor circuitry. These circuits are built on plug-in printed wiring boards similar to those shown in Figure 11. Due to circuit duplication these boards are not as complex or difficult to service as they might appear. As can be seen in Figure 11, each board is made up of several smaller printed circuit boards each performing a common logic function. By interconnecting these basic elements in various ways, all of the required circuit functions can be obtained. The components used on these boards are not subject to wear or deterioration with age. To further increase their reliability each board is sprayed with a clear plastic coating, making them impervious to dust or moisture.

The only relays or stepping switches used are those associated with the read-out. Since this occurs on the average at intervals of 10 or 15 min, and operates at relatively slow speed, maintenance is not expected to be a problem.

FUTURE SYSTEMS AND TRENDS

The functions performed by two systems have been described so that a better understanding can be obtained of what can be done with this technique. Industrial data processing is still in its infancy and advances are being made rapidly. One can predict with only questionable accuracy the role of data processing in the steel industry in years to come.

Each new data logging or data processing application must be able to perform additional valuable functions for the user or it cannot be justified. Glamorous as it may be, the recording of massive amounts of data is of little value unless the user can benefit from the information, either through production scheduling or recording, better payroll or accounting records or from accurate, extensive and easily referenced quality control records.

The present systems are chiefly tailored for application to one specific process or at most to include several related processes. As such, these systems are often difficult to justify since the gains may not be large enough to warrant the expense. The greatest gains will be achieved when it becomes possible to have a large scale system that has been engineered to include all the steel processes, from incoming order handling through customer billing. It is difficult to visualize the myriad details surrounding such a system now, but as the smaller portions are built, tried and found to have satisfactory performance and reliability, the next steps become increasingly clear.

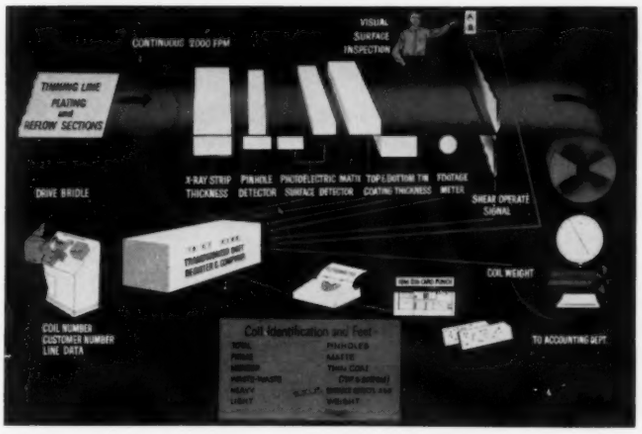


Figure 17 — Schematic block diagram of an electrolytic tinning line data logging system.

It is extremely important that anyone contemplating the use or installation of this type of equipment be fully aware of the details of what information, in what form, at what time, is needed from the process. Data logging equipment and more complex equipment such as computers will perform marvelous tasks but they will always remain "dumb" servants. They can do only the specific tasks for which they have been designed, and cannot exercise that "good business judgment" often exhibited by people.

For instance, if a data processing system were to include the order processing functions for optimum scheduling of the heats for a bank of open hearth furnaces, an elaborate specification of optimum conditions and factors would be necessary.

How do you handle a small order of a specialty steel? How are special short shipping schedules to be treated? How is the scheduling process altered by the furnace conditions or by the previous heat specifications? All these and many many more questions must be answered before the desired results can be achieved. The degree of success of the final system will be a function of the detailed analysis that has preceded the equipment specifications.

It can be seen from the foregoing that the field of data processing is not only a fascinating one but one with almost unlimited possibilities. We have been able only superficially to cover the subject here, just as the steel industry has only begun to make use of these new systems. There is little doubt that time will yield a greatly expanded use of data processing, and that those mills that make most effective use of such new techniques will in the future be the more efficient producers and have the greatest success in their efforts to automate their processes. ▲

by P. F. Walker, Assistant to Superintendent,
Service Division, Bethlehem Plant, Bethlehem Steel Co., Bethlehem, Pa.

Structural Steel Handling With

Figure 1 — Storage area west of the auxiliary yard was expanded and a truck loading area was established which is completely segregated from the plant roadway system.

Mobile Equipment

. . . . practically all truck shipments of structural steel are being loaded by lift trucks in a truck loading yard at rates of about 19,000 tons per month . . . . these rates can be doubled without adding truck equipment . . . .

Figure 2 — The 40,000-lb capacity fork trucks are used to load single lifts on highway trailers.

Figure 3 — Load make-up is accomplished through the utilization of 20,000-lb fork lift trucks.

Figure 4 — Material is transported to truck loading area by 50,000 and 60,000-lb straddle carriers.

THE Bethlehem plant of the Bethlehem Steel Co., as a major producer of structural shapes in the East, has had to face many problems in order to meet the increasing demands of the structural market. The initial consideration four years ago was to provide increased mill and finishing capacity, a program that was essentially completed late in 1956. One of the major new facilities was an auxiliary shipping yard, consisting of four crane runways with one crane each. The outside runways have 10-ton double-trolley cranes with 98-ft span and the inside runways have 20-ton double-trolley cranes with 120-ft span. These runways are 445-ft long and are served with a roadway and two railroad tracks at each end. Original plans called for the use of 40 rack-type railroad cars and four 50,000-lb straddle trucks to transport structural material from the main shipping yard to the auxiliary yard. (The straddle truck fleet has been increased to nine 50,000-lb and two 60,000-lb units.) Finishing equipment consisting of slitter, rotary straightener, cambering machine and a gag were installed in this area, leaving the balance of the space under crane runs for laydown, sorting and shipping. This auxiliary shipping yard was to account for approximately 20 per cent of the total shipments.

After several months' operation it became apparent that inventories of product between generation at the main yard and final disposition for shipment at both main yard and auxiliary yard must be increased to provide for the changing character of orders. That is, a greater stock of material must be made available to provide the make-up for the wide varieties of sections desired on a single customer shipment. Accordingly, all available yard areas adjacent to the auxiliary yard were layed out for straddle-truck storage. This extra handling could be accomplished economically only through the use of straddle trucks since once the loads were assembled on bolsters no further costs were incurred other than the transportation by the straddle trucks. It was this relatively inexpensive handling method that permitted the economical operation of the split shipping areas. The previous method would have been to load railroad cars with material to be stored, transport to storage area, unload with rail crane and chainmen to blocking placed on the ground; the reverse of which would be necessary to return the material to the respective shipping yard.

Figure 5 — The 20,000-lb fork lift trucks are used to load multiple lifts of structurals.

During this same period the demand for truck shipments of structurals to our customers was steadily increasing and posed a serious threat to our over-all shipping effort. The loading of over 700 trucks per month in both the main and the auxiliary yard created a traffic problem and interfered with the transfer of stock by straddle truck.

We were told however that truck shipments would be increased still further due to the change in character of orders. Therefore the question arose, "How to increase truck shipments without aggravating all the existing problems and over-burdened facilities?" Fortunately we had a very concrete idea of the plan to follow, an idea that had been germinating for two years was now activated. "Why not load all truck shipments in an open yard—away from finishing facilities, crane runs and rail car loading interference using large fork lift trucks?" A flow chart was developed to show this new concept of material flow and handling. We next determined the reasons for each movement and predicted any changes in movement that might result in the installation of a new handling system.

AN EXPERIMENTAL PROGRAM

The next step was to establish an experimental program to test our proposed methods through practical application. This had to be done without major changes in or interference with existing loading methods, yet it had to be extensive enough to prove beyond doubt that lift-truck loading was feasible.

We were fortunate in having a 15,000-lb capacity lift truck available in the plant at this time for the experimental phase. An area was set aside at the west end of the auxiliary yard to carry out this work. The experiment was highly successful and immediate plans were laid to expand our initial ideas.

Figure 6 — This straddle carrier, used to transport material to shipping area, has a capacity of 60,000 lb.

DEVELOPMENT OF AREA

One of our major problems was that of developing sufficient and suitable areas to put this new system into effect.

It was decided that existing storage areas adjacent to the auxiliary yard be expanded; this, however, posed two problems:

1. The displacement of an 850-car parking lot.
2. Extensive excavation and fill, installation of storm sewers, grading and roadway construction. (Approximately 200,000-cu yd of earth were moved in the development of the area.)

Management's approval was immediately granted and work was started. Through the close cooperation of the engineering, operating and service divisions the necessary work was accomplished in six weeks.

EQUIPMENT

We immediately estimated equipment requirements and set about to procure two 40,000-lb and four 20,000-lb pneumatic tired fork lift trucks. The 40,000-lb trucks were to be equipped with 102-in. forks mounted on a 14-ft wide carriage to provide the reach to pick up and place complete loads on a trailer in one lift. The wide carriage provided the span necessary to handle long sections without excessive droop. The 20,000-lb trucks were to be used for making up truck loads from the various straddle-truck loads supplied to the yard—the fork length on these units was specified at 60 in. and carriage width at 8 ft. All units were to be equipped with all-weather cabs and adequate lights for night-time operations.

PRELIMINARY TRAINING

Training of lift truck operators was initiated as soon as the first lift truck was made available. Four operators were trained simultaneously under the direction of mechanical engineer from the service division. After three days of instruction, these men were put on a probationary period of truck loading. In addition to lift-truck operators, it was necessary to train personnel as truck-loaders and truck-loader assemblers. Their training was accomplished mainly by on-the-job training, supervised by shipping yard foremen and personnel from the service division.

TRUCK SHIPMENT YARD

Upon completion of a new parking lot, it was possible to transfer our experimental loading operations to a portion of the former parking lot which required only

surface treatment. This, plus the arrival of three lift trucks, two 40,000-lb and one 20,000-lb and five potential operators, enabled us to make the transition from experimental operation to our first truck-shipment operation.

As additional areas became available, the lift-truck operations were expanded and the truck shipping yard was born. The small lift trucks (20,000-lb) are used primarily for load make-up. This load make-up consists of breaking down bolster loads into customer orders suitable for single-lift loading by 40,000-lb lift trucks.

When loads are not adapted to single lift, the 20,000-lb trucks are used for trailer-truck loading.

Long light sections of structural steel which have a tendency to deform when lifted by fork truck must be handled by two 20,000-lb trucks, each supporting an end.

Material for shipment is transferred by straddle truck from storage area to the perimeter of the truck-loading area and/or other area prescribed by the truck-loader assembler.

Control of trailer-truck traffic in this area was effected through the following methods:

1. A single gate (40-ft wide) for both exit and entry.
2. The scheduling of load pickup times.
3. The establishment of a holding area.
4. Complete segregation from the plant roadway system.

STORAGE AREAS

Selected areas in the direct line of the material flow were prepared as storage areas. These areas were rough-graded and then covered with approximately 6 in. of slag which served as a base. This base was then chinked with slag sand and in some cases sprayed with dust oil.

Storage areas are lined off in slots measuring 10 x 60 ft. In most cases these slots are set at a 30 degree angle to a 20-ft access roadway.

After all available area in direct line with flow of material was developed, it was necessary to provide additional storage areas to hold the large inventory of steel needed to accumulate complete customer truck loads. Some of these areas are as far as 1½ miles from the truck-loading yard. This, however, does not pose any problem when material is stored and transferred by straddle carriers.

IDENTIFICATION SYSTEM

To feed material efficiently into the truck-loading area, a system of material location and identification had to be developed. This system had to be simple, positive, and operative without extensive use of personnel.

We feel that the system decided upon at Bethlehem ideally meets the above mentioned requirements.

Each storage area is designated by a color, such as red, yellow, blue, etc. Slots in these areas are identified by a letter and number. Signs hung from cables strung between poles are used to identify slots. For each slot, there is one bolster color coded and identified to correspond to the specific slot.

As material is loaded in the main yard on one colored bolster and one plain bolster, the loader will enter the bolster identification on a cut slip which accompanied the material through the various mill operations.

After the material is loaded it is stored in the storage area as indicated by the bolster letter and number. The cut slip is forwarded to the order department. These cut slips are held in the order department until a complete truck load is accumulated. A schedule of truck loads plus the necessary papers (manifests, material pass and cut slips) are sent to the shipping department approximately 24 hours ahead of the scheduled pickup.

Working from the bolster identification on the cut slip, material is ordered into the truck loading area for load make-up and subsequent loading by fork lift truck.

WHAT IS AHEAD

While a lot of problems are yet to be solved, we have in the main reached our first goal—the loading of structural steel onto trailer-trucks utilizing fork lift trucks. Practically all truck shipments of steel are loaded in the truck loading yard by lift trucks. We are shipping approximately 19,000 tons per month under this new system. It is estimated that a 100 per cent increase in shipping tonnage can be effected without adding to the present lift-truck fleet handling structural steel.

Lift trucks, although not the cure for every handling problem, have eliminated congestion, hazards, and traffic problems which existed when trailer-trucks were loaded under crane runways. We feel that the application of high-capacity fork trucks could solve similar problems in other areas.

Discussion

PRESENTED BY

C. W. DUNN, Superintendent Utilities, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

M. B. ANTRIM, Assistant Manager, Maintenance and Construction Div., Lukens Steel Co., Coatesville, Pa.

ALLAN T. RICKETTS, Assistant Superintendent, Structural Shipping Yard, Bethlehem Steel Co., Bethlehem, Pa.

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

P. F. WALKER, Assistant to Superintendent, Service Div., Bethlehem Steel Co., Bethlehem, Pa.

C. W. Dunn: I am interested in knowing whether you have had any safety problems with lift truck usage to load the trucks, immobility on uneven ground, and the co-ordination of two trucks on a given member. Do you have much breakage on the material you are loading? I see that propane was not used on these trucks, is there any reason why not?

M. B. Antrim: Some of the pictures illustrating Mr. Walker's paper showed fork trucks loading nested structural shapes on trailer trucks. How is it possible to

get the prongs of the lift truck out after you put the beams on top of other beams that are already on the truck?

Allan T. Ricketts: I would like to add, first of all, that we have five structural mills rolling practically all sizes of structural shapes into our structural shipping yard at Bethlehem. When we load some of the combinations on a truck or railroad car, they are not all as pictured in the figures. In many cases a greater combination is required, some of the additional problems that the author refers to are the result of these combinations. Other complex problems arise from scheduling five structural mills to produce truckloads and carloads with a minimum inventory.

As to the particular problem that our chairman has raised relative to picking up a beam from a nest of beams, we can, by moving the lift truck to the end of the beam—and that was clearly shown in some of the earlier figures—insert the fork into the web of the beam, raise the beam, and by use of separators set the material on the separators to allow the lift truck to return to the side of the material and rise in the conventional manner. This can be done in the reverse manner when placing beams on top of other beams.

C. E. Pritchard: How seriously does an extended period of inclement weather affect the handling? As I recall the figures depicted quite a few open cabs, and I wondered how that and your ground conditions would be affected by inclement weather conditions.

P. F. Walker: In answer to the question on safety: I might remark that we have had only one very minor finger injury in the process of all the truck loading to date, using fork trucks. We believe that properly trained people, apprised of the hazards, will avoid injury.

Actually, we feel that our problems are somewhat less, insofar as hazards are concerned, in the truck-loading area with lift trucks than they were under the crane runways. With fork trucks we have a more positive hold on the material than with the hooks used at either end of the beam when handling with overhead cranes; also the workers are not required to work as close to the loads as with cranes.

Our experience has not shown any problems with immobility due to terrain—our yards are in reasonably good shape. The co-ordination of two units to handle a single unit load also poses no real problem—operator experience is the key to this. Breakage of material has been nonexistant—occasionally a beam or beams may be bent.

We do not use propane fuel on the units. Mostly it was a matter of expediency; we were in a great rush to get equipment on the job and took standard gasoline engines. We may or will, undoubtedly, convert to propane later when time permits.

As to the question on weather: there was some incongruity between the figures and the text of the paper. We said we had ordered lift trucks with cabs—and the figures showed only one or two units so equipped. The reason for this was the vendor could not supply the cabs at the time the trucks were delivered. We now have the cabs ready to be installed on the remaining trucks. The weather conditions are no different out in the yard than they would be under the open crane runways, so it resolves to the problem of ground conditions insofar as the mobility of the equipment is concerned. We were careful to design the yards for good drainage and believe, so far as water is concerned, that there will be no problem. As to snow and ice, we will do as they do on the roadways and highways, plow and salt. ▲

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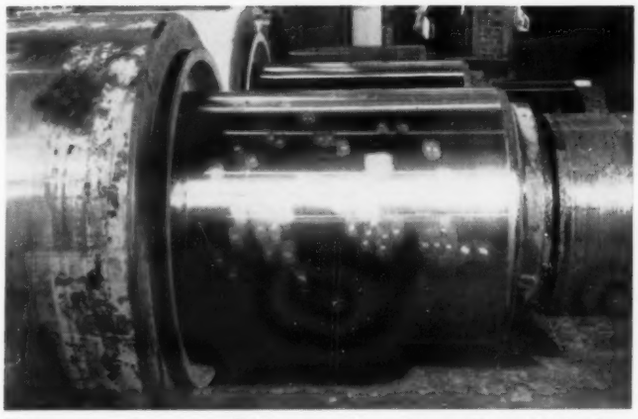


Figure 1 — Sparrows Point requires that roll necks be free of porosity.

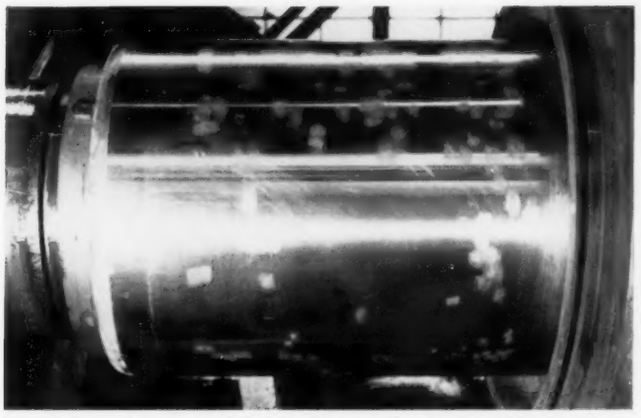


Figure 2 — It is easy to detect porosity defects after a short run.

Maintenance of Backup Roll Bearings in Strip Mills

by W. M. Lewis
Master Mechanic,
Sheet, Tin and Strip Div.,
Bethlehem Steel Co.,
Sparrows Point, Md.

. . . . there are no short cuts or compromises in good back-up roll bearing maintenance . . . . required are a good organization, adequate records, quality workmanship and proper methods and procedures . . . .

ONE of the most vital factors in strip mill operation is good maintenance of the backup roll bearings. This paper will discuss the practical approach successfully used to keep hundreds of these sleeve-type bearings in service for more than 20 years. Maintenance procedures here discussed will pertain almost entirely to the babbitted type bearings as applied to straight neck rolls.

JOURNALS (ROLL NECKS)

A sleeve bearing cannot operate on a journal that is not in proper condition. For successful use of a babbitted sleeve or shell in this service, several major requirements must be met. The journal must be sufficiently hard to give wear qualities; a shore hardness of approximately 40 is recommended. The journals or roll necks should be round and concentric with the body of the roll and the condition of the journal surface should be as nearly perfect as possible, free from surface defects and ground to an 8 to 12 micro-inch finish in the case of babbitted bearings. Grinding and polishing of these surfaces is done with a 180-grit grinding wheel developed especially for this job. A highly polished mirror finish has been found definitely to contribute to bearing failure. So positive is the feeling against high neck polish that all new roll necks so furnished are reground before they are put in service.

To clarify what is meant by no surface defects more detail is offered. Porosity is the worst condition found in cast roll necks (Figures 1 and 2). One of the requirements of all rolls ordered for use in the Sparrows Point plant is that the necks be free of porosity. Quite often the roll vendor has to install forged steel sleeves to accomplish this. Attempts have been made to close or hide the porous areas by welding. It is not easy to detect these short cuts before the neck is put in service, but all such spots or areas are readily detected after a short run. In too many cases they are detected after operations have been interrupted by bearing failure. There are no short cuts in preparing a journal that will give good bearing life.

NECK ETCHING

Probably one of the most difficult problems to solve in connection with journal maintenance has been neck etching. This etching can show up as a general condition over most of the journal area, but in most

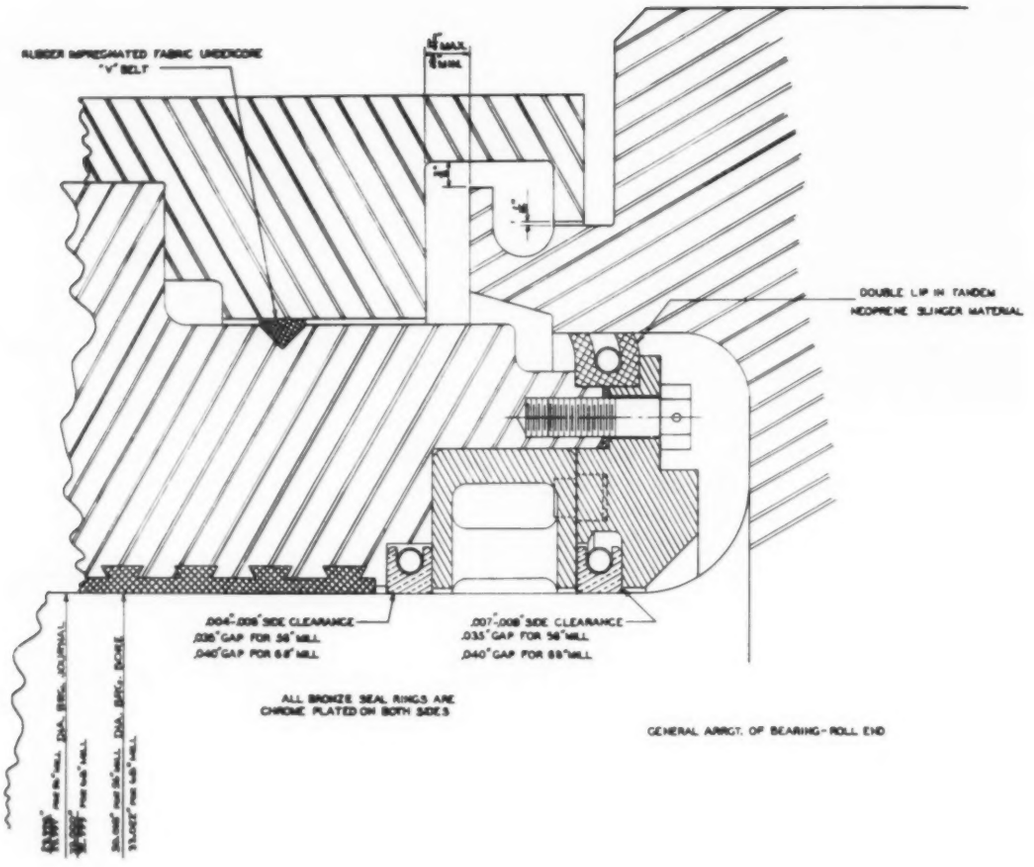

RUBBER IMPREGNATED FABRIC UNDERCORD "V" BELT
DOUBLE LIP IN TANDEM NEOPRENE SLINGER MATERIAL
.004"-.008" SIDE CLEARANCE .035" GAP FOR 56" MILL .040" GAP FOR 68" MILL
.007"-.008" SIDE CLEARANCE .035" GAP FOR 56" MILL .040" GAP FOR 88" MILL
ALL BRONZE SEAL RINGS ARE CHROME PLATED ON BOTH SIDES
GENERAL ARRGT. OF BEARING - ROLL END

Figure 3 — Schematic shows seal at roll body end of bearing.

cases it is worse, being confined to lines across the journal adjacent to the oil inlet holes when bearings are allowed to remain in one position on the neck for extended periods of time. The entire cause of this condition is not known but the extent and severity of the etching are associated with the amount of water in the oil when the rolls are removed from service. If the water content of the oil is in excess of 3 per cent when the roll is removed, this condition can occur in a comparatively short period of time. Some helpful practices have been used:

1. Rotate bearings on all idle rolls frequently (every two to four days).
2. Keep water in the circulating oil to one per cent or less—especially when roll is removed from service.
3. Occasionally add anti-rust compound as recommended by the oil vendor.

If the etching is not too bad, it can be polished with hand stones, but in questionable cases the journal should be ground and polished. In most cases removal of 0.002 to 0.005 in. on the radius is sufficient to restore the surface to excellent condition. Too much emphasis cannot be put on the control of this condition.

BEARING SEALS AND SHIELDS

Good control of bearing performance dictates that the best possible bearing sealing methods be employed. From information presented by various maintenance people over the past years, it must be admitted that there are good arguments in favor of several methods. It is the writer's opinion that there is much that needs to be done in the development of good seals and sealing methods. Several attempts have been made in the Sparrows Point plant to use soft seals in both hot and cold mills. However, all attempts made to date have not convinced the maintenance people that they are desirable. The lip-type soft seals are prone to fast failure without warning. Metallic seals as applied to bearing shells on straight roll necks have given the most consistent good service. This, therefore, is the type described in this paper. Until comparatively recently, the standard seal ring was made of aluminum bronze and chromium plated both sides. Recent experiments have been made with a high-grade iron ring, also chromium plated on both sides. At present, good performance with some saving in cost is indicated by using the cast iron ring. The improved performance in metallic seal rings is, to a large extent, attributable to the application of approximately 0.002 in. chromium to both sides (wearing surfaces of the rings). The use of these very hard wearing surfaces has extended the life of the seal rings to many times the original life. This hard surfaced ring has also equally improved the life of the ring spacers. These two factors combined made it possible to maintain the proper ring fits for much longer periods of time. This, of course, cuts oil losses, reduces oil contamination and extends bearing life.

The proper fitting of the seal rings is of major importance. All four rings in the bearings are straight cut and gapped. The rings are held tight around the roll necks with garter springs that fit into spring grooves on the outside of the rings. Before a ring is used, it is checked on a flat table to make sure it is flat and free from distortion. All rings must lay flat within less

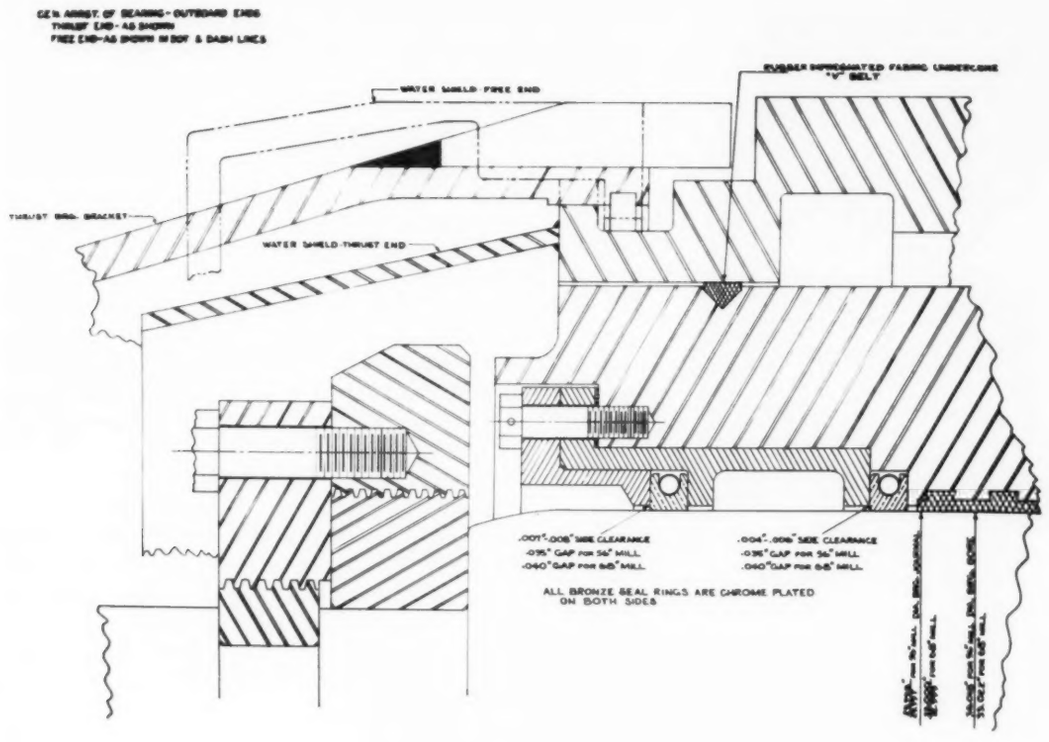


Figure 4 — Schematic shows seal at outboard end of bearing.

than 0.0015 in. under their own weight. Each ring is put on the roll neck in the area where it will work and with the garter spring in place. No space between the roll neck and the ring of over 0.0015 in. is permitted. With the ring in place as indicated the gap is checked and set as follows:

30-in. diam hot mill bearings—0.030 to 0.035 in.
30-in. diam cold mill bearings—0.020 to 0.025 in.
33-in. diam hot mill bearings—0.040 to 0.045 in.
33-in. diam cold mill bearings—0.025 to 0.030 in.

These gaps were determined by trial and theoretical calculations for average operating temperatures of the bearings in question. Some recent checks indicate that larger gap should be used on cold mill bearing rings.

All oil control (inside) hot mill rings are fitted in the ring spacers with 0.004 to 0.006 in. side clearance. Some additional clearance is required for the outside rings which are fitted to 0.006 to 0.008 in. These fits have all been determined after years of experience as the best for average good service. In the cold mill, all rings are fitted with side clearance of 0.003 to 0.006 in. Scale conditions in the hot mills make the additional clearance necessary. Rings stick frequently when too small clearance is provided.

Stainless steel garter springs are recommended for use on all seal rings.

To assure long life of the bearing seals it would be ideal to use a shielding method to keep all water and solids from contacting both ends of the bearings regardless of the type bearings used. This is especially true in the hot mill where large quantities of water and mill scale are encountered.

The methods used in the Sparrows Point hot mills are illustrated in Figures 3 and 4—Figure 3 showing the roll body end of the bearing and Figure 4 the outboard end. Note that a double-lip Neoprene seal is held in place in a groove around the outside of the bearing seal cage. The two lips when new actually contact the roll body. This forms an effective water dam. Only on rare occasions is any appreciable amount of scale found to pass this seal. A gap of about three in. is left at the bottom of the bearing to allow any water and scale that gets by the first and second lips to drain out and not be trapped in the ring area. This has proved to be an excellent roll body side water shield. It has not been necessary to provide any water shields on the outsides of the top-roll bearings. On the bottom rolls, shields where necessary are installed on both the thrust bearing side and the extractor side. On the extractor end of the roll it was only necessary to extend the lip on the original water shield ½ in. and pack a heavy-bodied roll-neck type grease in the groove. The thrust end had to be treated differently because of the extra movement of the thrust bonnets in relation to the bearing chucks. Note that a sheet-metal water deflector was welded to the top half of the bottom chuck to deflect the water away from the gap between the bearing retainer nuts and the end of the bearing.

MISCELLANEOUS TROUBLE POINTS

There are several other points where poor maintenance can cause bearing troubles:

1. The right length V-belt seals around both ends of the bearing shells. Belts that are too long allow crowding of the seals and prevent proper clamping of the chuck halves.

2. Good joint maintenance between the two half chucks. Poor surfaces often allow water and scale to get into the bearing.

3. Control of the outside diameter of the bearing shells. These shells often distort out of round through continued use and rebabbitting. It is most important to check the outside diameter after rebabbitting and machine if necessary to remove metal where dimensions

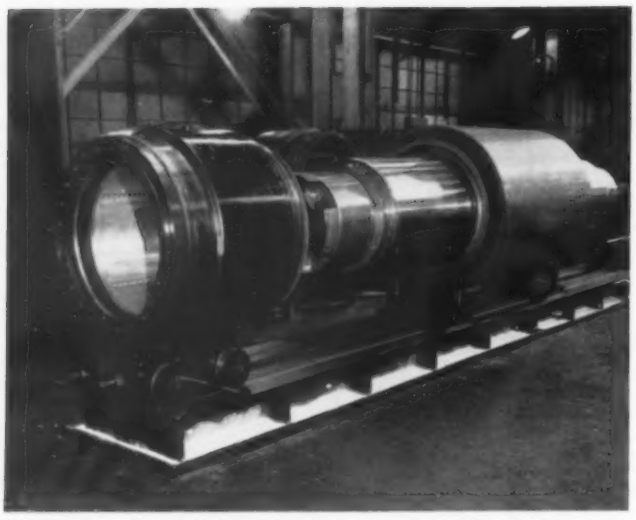


Figure 5 — A special assembly and removal stand is used in assembling backup roll bearings.

are in excess of maximum tolerance.

4. Maintain reasonable tolerances in the bearing chucks. These chucks should not be allowed to become too sloppy in the mill housings. Fits should be maintained in the work roll bearing box windows. It is very important that the thickness of the backup bearing chuck legs be kept the same on opposite sides of the mill (operator's side and drive side). This minimizes the end thrusts and resultant cross forces that exist when the center lines of the backup and work rolls are not parallel. Poor maintenance of work roll bearing boxes and work roll bearings can also contribute to bearing trouble. Uneven wear on bearing box side liner plates and roll neck bearings will allow roll centerlines to run out of parallel.

ASSEMBLY OF BEARINGS ON ROLL NECKS

Considerable damage can result if the best of care is not used in assembling the backup roll bearings on the roll necks. A special assembly and removal stand is used to properly do this job. Figure 5 shows this tool. Note the alinement wedges used for proper positioning of the bearing and the rack and pinion for moving the bearing shell on or off the neck.

BABBITTING OF BEARING SHELLS

With good maintenance practices the life of a bearing in this service could run into years. However, the time eventually comes when the shell must be rebabbitted (Figure 6).

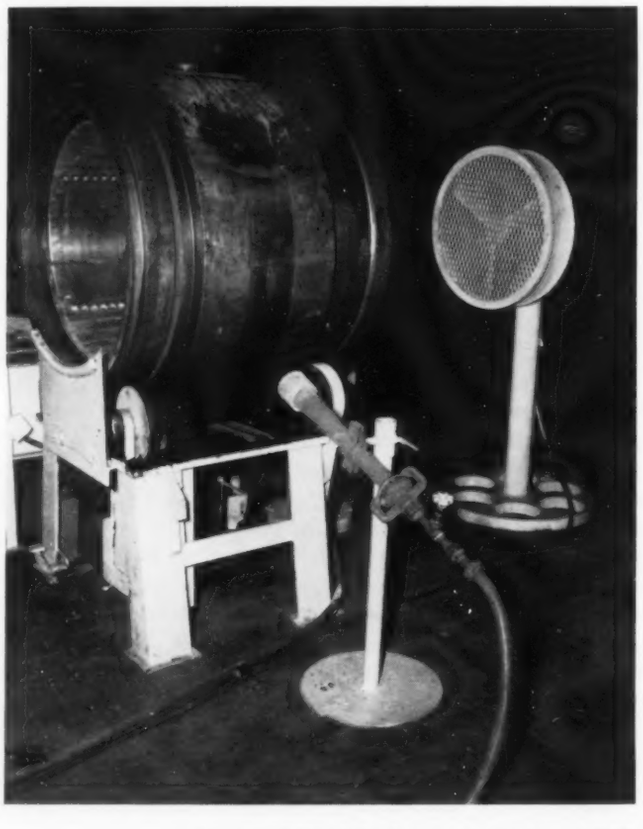
In the standardization of the puddling method of babbitting no concessions were made to the quality of material or workmanship. The method now used in doing this job gives better average results in both hot and cold mills than any other method. The following good points are evident:

1. Excellent quality of finished bearing.
2. Shorter time out of service for repairs.
3. Much cheaper costs.

The quality and workability of the 90 per cent tin-8 per cent antimony-2 per cent copper babbitt used in these bearings by the puddling method has at times been somewhat baffling to all concerned. Different batches of the babbitt mix have given different results—even when extreme care was taken to make them identical. No fundamental differences could be detected in chemical analyses of the different batches. In application the babbitt would bond poorly, have a brittle texture and have a large number of blow holes. Some of the worst working babbitt could be melted and bottom poured from a ladle into sticks in the weld shop and then be used with reasonable success. The method now used is to mix the babbitt in the plant foundry and pour it into small pigs. One thing that seems to be of extreme importance is the use of strictly top-grade metals. The pigs are remelted in the local weld shop and poured into sticks of about ½ in. diam, 30 in. long. The temperature of the babbitt is held between 600 and 650 F when pouring into sticks. All sticks are handled with clean gloves and wrapped until ready to use.

The preparation of the bearing shell for babbitting is very important. All recommended standard practices of cleaning have been tried, but none have proved worth the trouble, as no improvement in job quality or service life could be noted. To remove the old babbitt the shell is heated to a minimum of 300 F and held during the time the old metal is being removed. An oxyacetylene torch is applied directly to the babbitt to completely melt all of the old babbitt metal that is to be replaced. This method generally burns away any excess oil that has accumulated. With the shell still held at 300 F a high-grade metallic flux is applied to the surface and brought to a liquid form with the oxyacetylene torch. The surface is generally hot enough to melt the flux. It is then wire-brushed until the area is clean and tinned. A small amount of babbitt is

Figure 6 — Additional bearing life is obtained by rebabbitting the bearings.



applied at this time to assure good coverage and surface protection until layers of babbitt are applied. This operation is done in sections of about 8 in. square until the entire surface is prepared. After tinning operation is complete, an oxyhydrogen torch is used to fill in all of the bearing dovetail grooves by taking a 3-in. wide section across the bearing at a time. This floats all of the excess flux to the surface. The bearing is then allowed to cool to atmospheric temperature. Warm water and a wire brush is used to completely clean the surface. The shell is then heated to 200 F and the babbitt is applied by using an oxyhydrogen torch.

The babbitt is applied in a series of three-inch wide passes (Figure 7) across the bearing until the desired thickness is obtained. The surface is thoroughly wire-brushed between passes. All bearing-shell temperatures are checked and held by use of temperature sticks.

In cases of excessive wear on the pressure area of the bearing but where the bond is still good and the babbit is free of cracks and porosity, the worn area is machined to remove all bad babbitt surface. The surface is then built up to restore the seat to the original height. This is done with the same procedure as indicated above. The off-pressure side of the bearing is never disturbed unless some out-of-ordinary happening has caused serious damage to that area. Nothing can be gained in reworking an area of the bearing that is not in trouble. This statement is not intended to indicate that only spot repairs are made. The entire section that shows even spot troubles is reworked. The pressure side of the bearing is generally rebabbitted two or more times before repairs are needed on the off-pressure side.

MACHINING AND SCRAPING

After babbitting, the bearings are machined to the desired size. The 30-in. bearings are bored to 30.000 in. and then moved 0.015 in. off center towards the off-pressure side and re-bored. The 33-in. bearings are offset 0.025 in. After scraping and fitting to the journal, the recommended bearing diametral clearance is achieved. This clearance is 0.020 in. for the 30-in. bearing and 0.030 in. for the 33-in. bearing.

In the higher-speed cold mills additional bearing clearances were found necessary. To get the desired results it was necessary to bore the off-pressure sides of the bearings $\frac{1}{16}$ in. deep for the full width of the bearing except for a 4-in. wide band on each end. These 4-in. wide bands are machined and scraped to clearances given above.

In addition to giving the necessary internal clearance this alteration allowed better cooling and lower neck temperatures.

Rebabbitting of the pressure sides is recommended when a wear of 0.035 to 0.040 in. is reached. This gives an allowed bearing clearance of 0.060 in. before rebabbitting.

Standard fitting and scraping practices are used to properly fit the bearing surface to the journal. The pressure area of these bearings is approximately 120 degrees, but it is not practical to use this entire area as a load-carrying surface. It is the writer's opinion that the work area between 60 and 70 degrees is best. In practice the bearing surfaces are scraped back and an oil-

Figure 7 — Babbitting is applied in 3-in. wide passes.

wedge area is established on both sides of the bearing, tapering from zero at the pressure area to 0.020 to 0.030 in. at the oil inlet holes. This wedge extends to $1\frac{1}{2}$ in. from each end of the bearing.

The reason for cutting back on the pressure areas (Figure 8) is that it is too difficult to maintain an oil film through such a long circumferential travel under extreme pressures. As stated earlier in this paper, the necks are not highly polished. It is believed that this also helps in maintaining the oil film. All bearing surfaces are also treated by scraping shallow circular overlapping grooves over the entire surface.

To summarize and emphasize the aids to holding the oil film, the following repetitions are made:

1. Limit the length of travel of the oil in the pressure or load-carrying area.
2. Eliminate mirror finishes on journals.
3. "Rosette" the bearing surface to provide shallow oil pockets.

CARBON BUILD-UP

In operating this type bearing most maintenance people have learned that one of the worst enemies to bearing life is the so-called "carbon build-up" which

Figure 8 — Pressure areas are cut back in order to maintain oil film.

occurs when the load-carrying area becomes very dark or black after comparatively short time of service. When this surface becomes black and glazed, a bearing failure is almost sure to occur. Good practice dictates that this surface be reworked before it gets black and glazed. Scraping a surface of this type is an extremely difficult task; in most cases the bearings are therefore sent to the shop and machined to remove this build-up. In several check cases of both hot and cold mill bearings sent to the shop for machining to remove this glazed surface, it was found that when the bad surface was removed, the diametral clearance of the bearing was within 0.002 in. of its original fitted size. This was after removal of as much as 0.010 in. It is evident that at least two things happen in this case to cause bearing failure:

1. A poor bearing surface exists.
2. Necessary neck clearance is sometimes lost.

BEARING OIL

The condition of the lubricating oil should not be overlooked when attempting to get good bearing performance. It is important that the oil be kept as free as possible from contaminants at all times. As has been mentioned, much can be done with seals and shields, but to be realistic it must be taken for granted that it is not always possible to keep all of the many seals and shields in perfect condition. This makes it imperative that adequate means for cleaning and filtering be included in the bearing-oil system. Good filters should be installed between the pumps and the main header and also at each mill stand. On a recent installation, the need for a magnetic type filter was conclusively demonstrated. Centrifugal cleaning is provided on all strip mill bearing-oil systems in Sparrows Point. The writer cannot conceive the possibility of operating any hot mill bearing system without adequate centrifuge capacity. A maximum capacity of 4000 on one 10,000-gal system is provided. In most cases it is necessary to run only one of four centrifuges part time to keep the oil in good condition. However, there have been many times when full capacity has been inadequate.

It is not considered good practice to operate any backup roll bearing system with over one per cent water in the oil; three per cent is considered the danger point during operation. No bearing should be allowed to stay idle on a roll neck when the oil contains over one per cent of water. To assure this it is necessary to get the water content down to one per cent or less each time the mill goes down for general repairs and roll changes.

MAINTENANCE RECORDS

A good backup roll bearing maintenance practice must include a definite inspection and repair schedule. This can be accomplished only with an accurate and detailed maintenance record of every bearing in service.

Figure 9 shows a sample of one of the bearing record cards. Every bearing used in a hot mill should have an inspection and repair cycle of three months. Once every six months is normally adequate for cold mill bearings. All bearings should be checked for oil leaks each week early on the first repair turn. This should be done with normal operating oil pressure on the bearings and the mill down. The information thus obtained gives a good lead in determining which bearings need repair before being put back into service.

56" HOT STRIP MILL BACKUP ROLL OIL BEARING REPORT
BOTTOM BEARING NUMBER 6ET

DATE	RE-NEWED "V" BELTS	RINGS FITTED	WIPED	SCRAPED	BORE	ELEVATION	REMARKS	ROLL NUMBER
7-16-54	NO	YES	NO	RE-WORKED SEAT	30.018"	.817"	CONDITION GOOD	25746
9-15-54	YES	YES	NO	NO			BRG. SEAT CRACKED	25746
1-2-55	NO	YES	NO	NO			BRG. SEAT CRACKED	25746
1-14-55	YES	YES	NO	NO			BRG. SEAT CRACKED	21215
5-5-55	NO	YES	NO	RE-WORKED SEAT	30.019"		BRG. SEAT CRACKED	21215
7-12-55							BRG. RE-BABBITTED & RE-MACHINED	
7-26-55	YES	YES		FITTED TO ROLL	30.019"		INSTALLED ON NEW ROLL	69299
8-15-55	NO	YES	NO	RE-WORKED SEAT			CONDITION GOOD	69299
11-6-55	NO	YES	NO				BRG. SEAT CRACKED	69299
11-14-55	YES	YES	NO	RE-WORKED SEAT			BRG. SEAT CRACKED	69299
12-24-55	NO	YES	NO	RE-WORKED SEAT			BRG. SEAT CRACKED	69299
1-6-56							RE-BABBITTED & RE-MACHINED	
2-5-56	YES	YES		FITTED TO ROLL	30.019"		INSTALLED ON NEW ROLL	69296
3-25-56	YES	YES	NO	NO			CONDITION GOOD	69296
5-27-56	YES	YES	NO	NO			CONDITION GOOD	69296
6-3-56	YES	YES	NO	NO			CONDITION GOOD	69296
9-14-56	NO	YES	NO	NO			CONDITION GOOD	69296
11-30-56	NO	YES	NO	NO	30.022"		INSTALLED ON NEW ROLL	31518
1-5-57	NO	YES	NO	NO			CONDITION GOOD	31518
1-19-57	YES	NO	NO	NO			CONDITION GOOD	31518
3-30-57	YES	YES	NO	RE-WORKED SEAT			CONDITION GOOD	31518
6-22-57	NO	YES	NO	NO			CONDITION GOOD	31518
7-15-57	NO	YES	NO	NO			CONDITION GOOD	31518
8-25-57	YES	YES	NO	NO			CONDITION GOOD	31518
1-12-58	YES	YES	NO	NO			CONDITION GOOD - LONG RUN IN SLOW SPEED MILLS	31518

Figure 9 — Cards are used to keep record on bearings.

SUMMARY

All maintenance people are interested in a minimum of mill delay and low maintenance cost. Good backup roll bearing maintenance is a major item in strip mill operation. This is possible with a good maintenance organization, adequate records, quality workmanship and the proper methods and procedures as previously stated. There are no short cuts or compromises in good backup roll bearing maintenance.

Discussion

PRESENTED BY

SAMUEL CARSON, Field Engineer, Morgan Construction Co., Worcester, Mass.

W. M. LEWIS, Master Mechanic, Sheet, Tin and Strip Div., Bethlehem Steel Co., Sparrows Point, Md.

A. E. CICHELLI, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

Samuel Carson: Mr. Lewis's paper deals with the babbitted type bearing as applied to straight neck rolls but one would expect that some of his points would be applicable to taper neck rolls with sleeve type bearings. We appreciate the fact that he refers to fitted bearings and not to clearance bearings.

1. In referring to the grinding of the roll necks, Mr.

Lewis has stated that "a highly polished mirror finish has been found definitely to contribute to bearing failure." This is a very broad statement in view of the thousands of highly polished mirror finished journals operating successfully on heavily loaded backup rolls, some for more than twenty years. I should like to hear Mr. Lewis go into further detail on this conclusion.

2. Since the roll manufacturer must often install forged sleeves to overcome porosity in roll necks and, since he tries to hide such porosity by welding which is detected in too many cases by interrupted operations due to the bearing failures they have caused, is it not advisable to specify forged sleeves on all roll necks?

If the etching of roll necks is severe and repetitive, how many times is it possible to regrind the necks before they must be fitted with new sleeves?

Mr. Lewis is probably correct in associating the water content of the oil with this etching and better seals than have yet been developed will be welcomed by the rolling mills of the world. Although we have had improved materials and are not yet satisfied we do find the soft seals are doing an excellent job in keeping the rolling solution out of the bearings in most installations. We look forward to the development of a seal that will keep water out of the bearing to the same high efficiency with which oil is now prevented from leaking from the bearing.

3. Has Mr. Lewis found "carbon build-up" common to bearings in all of his mills? We would be interested in knowing what attempts were made to remove this carbon before resorting to remachining.

W. M. Lewis: I expected to get called on the comment I made with reference to highly polished roll necks. There is a difference of opinion as to just how a roll neck should be finished. Our experience with these journals dates back some period of years. It was brought to our attention very conclusively during one of our most trying periods in our 56-in. hot mill. We found during that time that we put new rolls into the mill with mirror finished necks and new bearings, and in a matter of a very few hours we had bearing failures.

We took these same necks out of service after bearing failure and ground the necks and polished them to an 8 to 12 micro-inch finish as I indicated in the paper, and with the same type bearings and all conditions as nearly the same as we could physically make them, these rolls and bearings would consistently give excellent runs.

This experience was identical on several different occasions, and it led us to associate neck conditions with bearing life. Since this period, 1943 or 1944, we have tried at different times to run highly polished roll necks on babbitted bearings. We have had an occasional one that did run; but in by far the most cases, we had bearing trouble in a comparatively short time. This is only the result of trial and error on our part, and we are convinced that the highly polished neck did contribute to some of our bearing troubles.

I believe the next question Mr. Carson asked was regarding forged steel sleeves. In the interest of economy, we think it best to order our rolls from the roll vendors with rigid requirements for good necks. It is not necessary to sleeve all of these necks. In fact, it is necessary to sleeve considerably less than 50 per cent of these necks. It would not be economical from a purchase standpoint or from a roll manufacturer's standpoint to specify that all necks be sleeved.

I do not believe Mr. Carson's statement regarding seals requires more comments from me. He evidently takes some exception to the statement I made with reference to the type seals that were most satisfactory. I would like to comment just a little on that. I know hot mills in the country that are successfully using soft seals on the type bearings we use. We have attempted to duplicate that particular mill's performance, and we have failed in every attempt. Therefore, we are pretty well satisfied that we will continue to live with the metal seals.

In reference to Mr. Carson's question dealing with carbon build-up, we try on our periodic inspections of these bearings to remove the dark surfaces and re-scrape the bearing surfaces. In that way it is possible to keep abreast of the problem and keep our bearings in good condition. There is an occasional bearing that we, through mistake, or through lack of time to get to that bearing in its regularly scheduled cycle of inspection, that carbon deposit gets out of control. In cases of this type, we do send the bearings to the shop and have them bored.

A. E. Cichelli: Mr. Carson has raised some very interesting points. Probably, the question of fitted vs clearance bearings (as they apply to these heavily loaded strip mill type) should be reviewed for a moment.

The oil film has to support the load, and the thickness of that film depends on the rotational speed of the journal, its diameter, the load, the oil viscosity and the radial clearance. The latter is the difference between the radius of the bearing and the radius of the journal. You might recall Mr. Lewis used the expression, "internal clearance," which he stated was in the neighborhood of 0.030 in., or about 0.001 in. per in. of diameter. This is distinct from the radial clearance, which is of interest, if I might say, to the oil film. As the radial clearance approaches zero, the clearance bearing approaches the construction of a fitted bearing. The value of the radial clearance plus the balance of the space around the journal adds up to the internal clearance mentioned by the author.

From an earlier study made of these bearings, we conclude the film thickness is in the vicinity of 0.0005 in., or less, at high peripheral speeds and loads, and that this is possible, not with large radial clearances, but with one of about 0.0015 in. Theoretically, a large radial clearance, under these extreme conditions, would render the establishment of a film more difficult than a small radial clearance.

The fact that the bearing has 0.030 in. internal clearance has no meaning with regards to the oil film thickness. As far as clearance is concerned, it is the radial clearance that influences film thickness, and from a knowledge of a few other variables, it is possible to calculate what that thickness must be to float the roll.

Thus, the fitted bearing is not a fitted bearing, after all. Not only theoretically must there be a small radial clearance, but as a matter of record, careful measurements confirmed the existence of a small radial clearance even though the bearing had been initially scraped in. We believe further that, even assuming the bearing and journal do not have reasonable radial clearances to begin with, the high loads (over 11,000-psi peak pressures) will produce both deformation and wear in the

bearing metal, causing it to conform to the required dimension. We might say that, because of severe loading on them and whether their radial clearance is large or small, both the clearance and fitted bearing become small-clearance bearings under load. The fact that the same type of wear has been experienced on each type of bearing we think lends support to our theory of conformability.

As for the question of surface smoothness, whether in the journal or the bearing, the fact that under a heavy load, the bearing and journal surfaces are nearly parallel helps to explain the improved results experienced when these two surfaces are purposely "roughened." When two surfaces are in parallel, one moving with respect to the other, were it not for the imperfections in the two surfaces, there would be no wedge formation, no oil film. The presence of tiny ridges and mounds produces eddies of oil, and film pressure develops to separate even apparently parallel surfaces. The need for "roughened" surfaces increases with load and more particularly as the radial clearances become smaller and smaller.

It appears then that when there is a carbon buildup, the valleys become filled with carbon and film formation becomes increasingly more difficult. Only by removing the carbon and restoring the tiny ridges can we correct the condition. It is also well to point out that oil in the valleys in a "rosetted" bearing facilitates film formation during threading speed.

The cause of this carbon build-up is very likely the high skin temperature in the load zone, which causes gradual oil breakdown. Thermocouples buried in the babbitt of the fifth stand of a 5-stand tandem mill disclosed temperatures to be in the order of 200 F. It is reasonable to assume the oil temperature itself may have exceeded that by a considerable amount.

Years ago when you were first experimenting with the re-babbitting of this style bearing, I recall your salvaging one shell by removing all anchor grooves and covering the surface with a layer of bronze-weld. That latter surface was machined to a smooth finish and then babbitt-welded. You were endeavoring to evaluate the bonding technique at the time. Can you bring us up to date on that shell?

W. M. Lewis: Before I answer Mr. Cichelli's questions, according to my notes I failed to answer a couple of parts of Mr. Carson's questions. I believe he asked how much we would allow on the grinding of the neck to get away from etching marks before that neck was no longer good. We have successfully operated bearing journals to approximately 0.025 to 0.030 in. under size. We do not recommend going any more than 0.030 in. under the original sizes of the journal.

I believe there was another question that I ignored. This was in reference to the carbon build-up and asked whether or not that carbon build-up was typical to all bearings we have in service. It is typical of all babbitted bearings we have in service. Our experience with aluminum bearings has not been extensive enough for us to form any accurate opinion about carbon build-up on aluminum.

Mr. Cichelli wanted to know, I believe, what happened to an old bearing we termed as scrap. This bearing was one that we allowed to stay in service a little bit too long, and it wore down through the babbitt and quite some distance into the steel.

In an effort to salvage this bearing, the pressure area was brazed and machined to allow $\frac{1}{8}$ in. thick babbitt. This bearing has a history of rebabbitt every year since it was repaired. I do not want to get into any theoretical discussion about bonding materials; but this bearing, today, is considered ready for some other experiments. ▲

1959 AISE

SPRING CONFERENCE

April 27, 28, 29

Hotel Statler

Buffalo, N. Y.

Tackling Water Pollution

by E. G. Paulson,
Engineer,
and Everett P. Partridge,
Director, Hall Laboratories,
Division of Hagan Chemicals and Controls, Inc.,
Pittsburgh, Pa.

. . . . management should place the water program in the hands of a person with responsibility and authority . . . . with the help of specialists he should develop the optimum method of handling each pollution problem with respect to the actual conditions in the plant . . . .

BY 1975 there will be one more person for every five now living in the United States. Each of these new additions will require more water directly to satisfy his domestic requirements and indirectly to provide the products of industry he will demand.

To build the autos in which all these people will move without ceasing and the roads over which they will travel and the refineries which will produce their gasoline, we shall obviously need to manufacture more of everything, including steel. Extend this picture to include all of the items we human beings are conditioning ourselves to believe essential. It is easy to see that the increased production of our existing industrial plants will insure that they will be asking for more water, while many new plants will be demanding their share.

WATER FOR INDUSTRY

As indicated in Figure 1, on an average day in 1955, industry was withdrawing 111,000,000,000 gallons of water from our lakes and streams and underground flows (1).* Some concern has been expressed as to whether there will be enough water to go around in the future. Last year a trade journal featured an article, "Is American Industry Dying of Thirst?" (2).

The answer is, "Of course not!" for industry actually consumes only about two per cent of the water it withdraws, returning the rest for someone else to use. What is called "first water" is, however, becoming continually harder to find.

Industry is facing up to the fact that water is no longer free, that it must be conserved, used and then reused, perhaps many times. Each company is naturally concerned, however, about just who picks up the bill for keeping the water usable.

There can scarcely be any misunderstanding as to who must ultimately pay the entire cost for industrial as well as domestic water; each of us as individual consumers of everything produced by industry must dig into our individual pockets. But the manufacturing plant which

* Numbers in parentheses refer to Bibliography at end of paper.

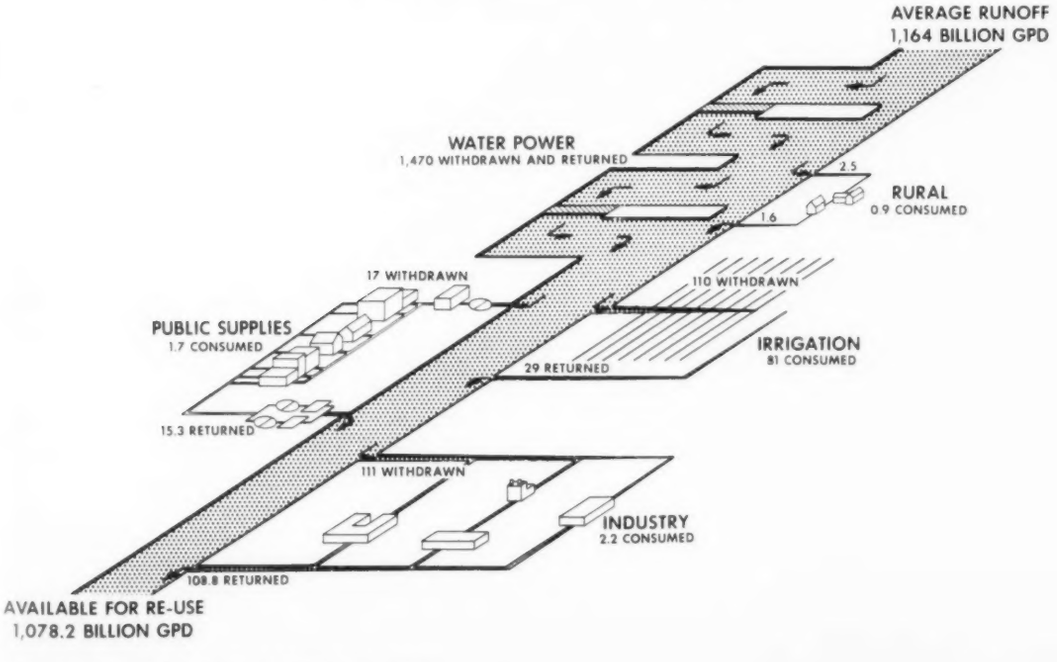


Figure 1 — Chart shows withdrawal and consumption of water in the United States in 1955.

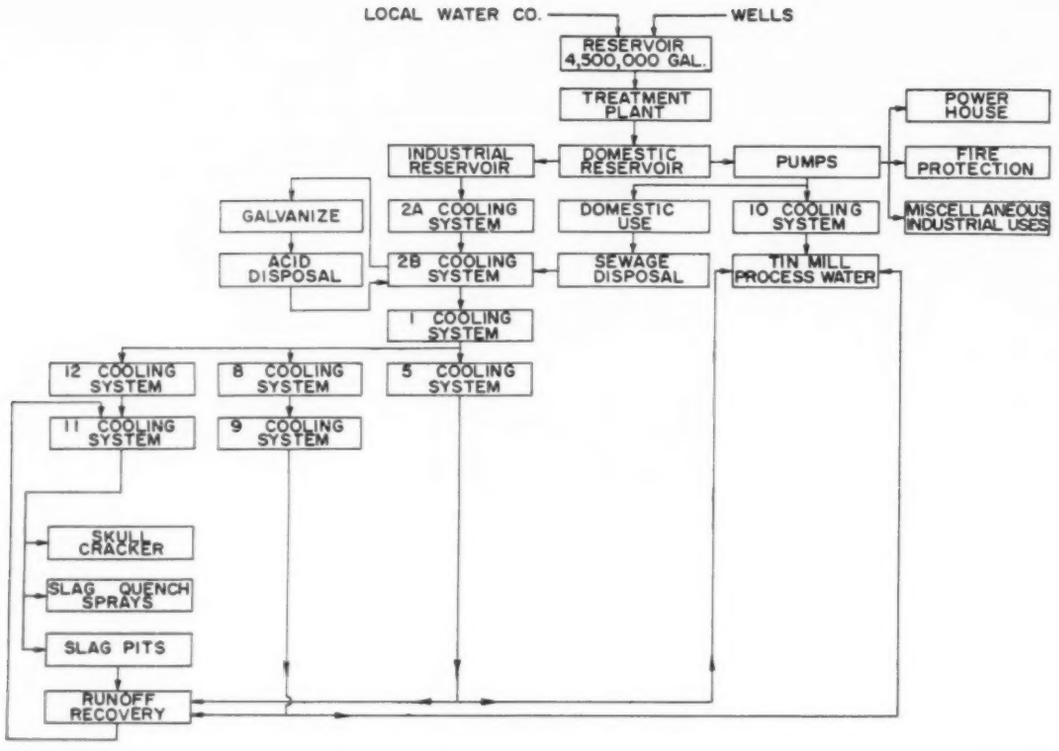


Figure 2 — Water is extensively reused at the Fontana plant of Kaiser Steel Corp.

must transmit to its customers a greater increment for the cost of cleaning up its waste water naturally feels put upon if its neighbor or its competitor is not required to do likewise.

Distributing with a just and even hand this cost of reconditioning water is no simple problem. In the main it is being accomplished by a slow but relentless pressure from regulatory boards. More and more it is being aided by the responsible attitude of professional industrial management.

MINIMIZING THE COST OF USING WATER

The basic problem is, of course: How can this necessity of human life and universal raw material of industry be kept usable at the lowest total cost to each plant as well as to that ultimate aggregate of you and me known as society, which must pay the final bill?

The basic answer is: It is usually least expensive to control contamination right where it enters the water and to limit the contamination to the smallest practical amount of water.

Such an attitude is precisely opposite to the old, free-wheeling policy of trying to flush away contamination in the largest volume of water possible so that it would be diluted down to an unobjectionable level. That policy was adequate in the early days of industry and is still justifiable in some localities. But as more and more of our available water is inevitably re-used more and more times, and as industry continues to demand water of better and better quality, the sum of several individually endurable increments of contamination exceeds the level at which treatment is required to allow still further use. To recondition the large flow of water entering each plant to take care of what is still a very low concentration of the various contaminants is, however, very expensive. Economics then dictates a more practical engineering approach: removing for disposal or reconditioning the final contaminated water from each plant at the highest concentration of contaminants compatible with satisfactory performance in the final operation in which the water is used in that plant. As a result of this approach, the waste treatment plants of the upstream neighbors become an integral part of a water treatment plant.

WATER IN THE PRODUCTION OF STEEL

So far, we have been talking broadly about all industry. What about the manufacture of iron and steel?

Once-through use of water—Steel mills first grew up only where water was freely available. This is reflected in the figure of 65,000 gal widely quoted since 1950 (3) as the average amount of water employed in making a ton of steel. Obviously, this water is not consumed. Taken from a river or a lake, most of it is used for cooling on a once-through basis, then is returned to the source.

Also back to the source without any attempt at control until relatively recent times went a variety of contaminants, pickle liquor and mill scale, palm oil and soluble oils, acids and alkalis from the tin mill, organic wastes from the by-product coke plant. Only within the past two decades has serious effort been expended on keeping these out of the mill effluents. But less than a decade ago, the new viewpoint had progressed so far that an objective in the design of Fairless Works was to return water to the Delaware River of as good quality as that pumped from it (4).

Even in a new mill, attaining such an objective takes money and takes space. For example, at Fairless Works $4,000,000 was invested in facilities for treating waste water. These occupy 40 acres of the 2000-acre site.

MULTIPLE RE-USE IN A STEEL MILL

In the design of another modern steel mill an entirely different approach was dictated by the twin facts that

water is hard to get and waste water is hard to get rid of in Southern California. The Fontana plant of Kaiser Steel Corp. was accordingly built to swallow its own wastes to a large extent. We have derived the following discussion from a concise description presented recently by Riegel (5).

At Fontana only from 1400 to 1600 gal of water are withdrawn from the supply per ton of steel produced. This is less than 2.5 per cent of the figure of 65,000 quoted for the steel industry as a whole. How the water is used progressively through the plant by taking the blowdown from one cooling system to supply makeup to the next is indicated in Figure 2.

Water from the industrial reservoir enters the No. 2A cooling tower system, where it is recirculated through the motor rooms and heating furnaces. Evaporation of water in the cooling tower concentrates the substances initially present in the water. To limit this accumulation of dissolved solids, water is blown down continuously into No. 2B cooling tower system.

In the No. 2B system, the water is used for mill cooling and for flushing mill scale to the scale pits. Small particles of scale suspended in the water are removed in three large clarifiers and discharged to sludge beds. The clarified water is recirculated to the cooling tower. Water from the No. 2B system is used in the galvanizing operations.

Blowdown from the No. 2B system enters the No. 1 system. Here it is recirculated for cooling the open hearths, blast furnace No. 1 and the coke plant. The blowdown from the No. 1 cooling tower then is distributed to systems No. 5, No. 8 and No. 12.

In No. 5 cooling tower system, the water is used in washing gas and flushing the precipitators of blast furnace No. 1. A thickener removes suspended flue dust, which goes to sludge beds, while the water is recirculated to the cooling tower. The low-quality blowdown from this No. 5 system is used for some purposes in the tin mill and the remainder goes to the slag pits.

No. 8 cooling tower system serves blast furnace No. 2, discharging its blowdown into No. 9 cooling tower system. Here the water is used to wash the gas and flush the precipitators of No. 2 blast furnace. The blowdown from No. 9 system, like that from No. 5 system, goes to the slag pits and the tin mill.

Water recirculating in No. 12 system cools blast furnace No. 3. Blowdown passes to No. 11 cooling tower system for washing gas and flushing precipitators. Part of this low-quality water is pumped to the sprays for quenching slag, where it is evaporated. Water recovered from the slag pits is returned to No. 11 system.

High-quality water from the domestic reservoir is supplied to No. 10 tower system for cooling in the tin mill. The blowdown from this system is used for process water in the tin mill.

The effluent from the sewage disposal plant is not wasted, but is introduced into the No. 2B cooling tower system.

COST CONSIDERATIONS

The capital investment in the water system at Fontana, with its many cooling towers and pump stations, has been estimated at three times what would have been required if the plant had been located on the shore of a lake containing water of good quality. Total pumping costs have also been stated as about three times that of primary pumping for a once-through system; approximately 10 per cent of the plant power is used for pumping water.

This sounds uneconomical until we remember that this plant does not have to spend money for treatment of waste water. Another advantage of a recirculating system over once-through cooling is that chemical conditioning becomes feasible. Corrosion, scale and slime can be controlled more effectively with an over-all saving in cost of maintenance.

TACKLING SPECIFIC CONTAMINANTS

New steel mills are not likely to replace all our older facilities for many years. We must live with these going operations, attempting steadily to help them conform to the needs of society for water which can be re-used at the lowest total cost. This means tackling individual problems of what to do in each plant about such products as flue dust, the effluent from scale pits, pickle liquor, phenols and cyanides from by-product recovery.

Before dealing with specific constituents, we would like to reiterate the steps which should be taken to insure that the wastes arrive at the treatment facilities in the state most convenient for treatment and in a quantity of water most economical for treatment. One principle cannot be repeated too often nor emphasized too much: The study to develop the basis of design for waste treatment facilities should start with the manufacturing process which is responsible for the introduction of the waste contaminant (6). The general steps involved in a plant-wide water study can be summarized as follows:

1. Fact finding.
2. Analysis of data.
3. In-plant and/or process changes.
4. Removal of contaminants by either waste disposal or recovery systems.
5. Year-long operation of treatment facilities.

There is an adage that for every cure there arises a new problem. Steel mills are presently installing equipment for converting iron to steel by the use of oxygen inverter units (7). When using this process, finely divided iron oxide particles and gases are released from the inversion vessels. To avoid air pollution the gases must be washed before release. However, this creates a water pollution problem. The finely divided iron oxide dust is less than five microns in size so that the water bearing this dust must be clarified by the use of coagulants to make it suitable for discharge.

MILL SCALE

Armco Steel Corp. has provided an outstanding example of progressive improvements in the handling of the water problems in its continuous strip mill at Middletown, O. (8). Initially, water was used once-through, with only conventional scale pits to trap mill scale before the effluent went to the sewer on its way to the river. Increasing production led to the installation of specially designed sedimentation basins. Finally, clarifiers were added to allow recycling of the effluent to the mill at the same time that additional water from the

TABLE I
Quality of Effluent from Continuous Strip Mill After Different Methods of Treatment

	With continuous sedimentation (discharged to sewer)	With added clarification (recycled to mill)
Suspended solids (ppm)	40–60	10–20
Turbidity	...	3–8
Iron (ppm)	3–7	...
Oil (ppm)	14–20	<1

river was prepared for use in the processing departments. This conservation of water was imperative because increasing plant demands, coupled with a deficiency in rainfall for several years, had caused a serious drop in the level in the wells supplying water for processing.

How much was accomplished in the improvement of the mill effluent by adding clarification to the sedimentation step is evident in Table I.

Recovery from the combined treatment system has ranged from 176,000 to 206,000 lb of scale daily. The larger particles from the continuous sedimentation basin comprise approximately 70 per cent iron oxide and 30 per cent water. The filter cake of sludge from the clarifier averages about 40 per cent iron oxide and 45 per cent water, the remainder being largely suspended solids from the incoming river water.

Ferric sulphate has been used as the coagulant, with addition of lime for control of the pH.

OIL

Oil-bearing waste waters are common to all steel operations. For purposes of treatment it is essential to differentiate between truly soluble oil, emulsified oil, and insoluble oil. We have had the embarrassing experience of trying to break a supposed emulsion of a soluble oil which was actually in true solution in water. However, using the terminology of the field, in this discussion "soluble oil" will mean an emulsified oil.

Recently these oil wastes, both soluble and insoluble, have been treated by the use of flotation systems with either a pressurized influent or pressurized recycle as a means of expediting the rate at which the oil is separated from the water. In the case of a soluble oil, it is still necessary to first pretreat the solution to break the emulsion. This can be accomplished by utilizing a salting-out effect, pH adjustment, or a combination of the two.

The retention time in a flotation unit is generally of the order of 20 min, in a clarification unit more of the order of 90 to 120 min. A flotation unit handling a given volume of wastes would accordingly be smaller. However, since the retention time is so short, control of the unit and variations in the composition of the influent may have more effect on the operation of the unit and the quality of the effluent discharged. It is believed that the trend is toward pressurizing recycled effluent rather than pressurizing the influent, although plants have been and are still being installed which pressurize the total influent.

One phase of the treatment of oil-bearing waste waters which now appears to be receiving more attention is the reduction of loss at the point of origin. A novel process is catalytic emulsion breaking which promises recirculation of the oil along with removal of the water and some of the impurities from the system. More usual are oil purification systems such as filtration, magnetic separation of steel particles from cutting oils, and means for preventing bacterial activity in the soluble oil which would require dumping the batch. In evaluating the economics of installing an oil recirculating or recovery system, do not forget that discharge of this oil would result in an expenditure either in waste treatment facilities or chemicals. This should be considered as part of the present operating costs compared to the cost of recovery.

PICKLING ACID

If a person were asked to name the one problem in water pollution abatement upon which the most study has been performed and the most articles written, disposal of pickling acid would undoubtedly be the first selection. The steel industry has tried in many ways to get rid of the billion gallons or more of pickle liquor coming out of its operations each year. This unwanted by-product has been poured into abandoned mines, deep wells, exhausted oil and gas sands, and limestone formations. It has been lagooned in slag dumps. It has been trucked away at a cost of 2 to 4 cents per gal. Directly or indirectly, some of it still flows into lakes, rivers and the ocean.

Treatment of pickling acid runs the gamut from simple to complex. Straightforward neutralization with lime and disposal of the resultant sludge of iron hydroxides and calcium sulphate is most practical for smaller plants. Several much more complicated chemical processes are under consideration at present for operations on a larger scale.

The *Ruthner process* has been used commercially in three plants outside the United States (9). Here it has been operated by the Blaw-Knox Co. on a pilot-plant scale at Niles, O., with the co-operation of seven steel companies. The results of these studies are now being evaluated.

Because it recovers sulphuric acid for re-use in pickling as well as iron oxide which can be returned to the blast furnace, the process seems attractive. It solves the waste disposal problem without producing a number of undesirable by-products.

The process, as illustrated by Figure 3, consists of steps for concentrating the spent mixture of ferrous sulphate and sulphuric acid, then converting the ferrous sulphate to sulphuric acid and ferrous chloride by the use of hydrogen chloride gas. The ferrous chloride is separated from the sulphuric acid and then roasted so as to convert the ferrous chloride to hydrogen chloride gas and iron oxide. The sulphuric acid is degassed and returned to the pickling tank. The hydrogen chloride gas from the roaster and degasser is absorbed and stripped for return to the reactors.

One current opinion holds that the process should be economically applicable to plants which now use in pickling the equivalent of 8000 or more tons of 100 per cent H_2SO_4 per year. The process looks more attractive where continuous rather than batch pickling is used.

Another proposed process employs pickle liquor for *scrubbing coke-oven gas* after the tar has been removed (10). Ammonia in the gas neutralizes the acid, forming

ammonium sulphate in solution, while hydrogen sulphide precipitates the dissolved iron as ferrous sulphide. Iron ferrocyanide is also formed. Separation of these products requires additional process steps. The ferrous sulphide is oxidized with air or oxygen to produce ferric oxide and elemental sulphur. During this step the pH is controlled at about 7.9 to keep the iron ferrocyanide from dissolving. The sulphur is recovered by flotation as a product of 95 per cent purity. The residue is leached with alkali to dissolve ferrocyanide. The ferric oxide goes back to the blast furnace. Ammonium sulphate is crystallized from the end liquor.

A third process recovers *ferrous sulphate monohydrate* from the spent pickling acid (11). As shown by Figure 4, this process consists basically of concentrating the pickling liquor, adding the make-up requirements of fresh acid to the concentrated liquor, which results in decreased solubility of the ferrous sulphate, and separating the ferrous sulphate monohydrate which crystallizes out. This system results in recovery of the sulphuric acid, but also in the production of ferrous sulphate monohydrate. If a market is developed for the ferrous sulphate monohydrate, or if sulphuric acid manufacturers can be located who will use this as a starting material for their acid production, then for all practical purposes a closed system results.

Commercial plants using this recovery system have been in operation in Germany for approximately three years. It appears that this process bears consideration when the spent pickle liquor discharged is more than 40,000 gal per day.

Electrolytic treatment using anion exchange membranes is a fourth possible method (12). This is basically a system for regenerating the spent pickle liquor by removing the iron on exchange membranes. Laboratory studies on this system have been reported in the literature, but no semicommercial units have been installed to the best of our knowledge.

Assuming that the technology of any process has been perfected, it will then become a matter of economics as to whether it is cheaper to discharge pickling acid and possibly treat it by neutralization, or to install a recovery system. Each plant requires an individual study for its own particular problem.

In considering the possibility of utilizing recovery systems for disposal of waste pickle liquors, it appears that the smaller plant is at a disadvantage. It might be worthwhile in certain areas for these plants to consider a co-operative recovery unit to handle their needs. This appears feasible, for example, in locations such as Hamilton, Ontario, as well as Cleveland and Youngstown.

PHENOL

Whether recovery of phenol should be attempted depends on the origin of the waste stream, the pretreatment required, and characteristics such as concentration of phenol, consistency and content of suspended solids. If these factors are favorable, stripping can be accomplished by distillation with steam or by extraction with a solvent. The latter process has been aided by the development of solvents specific for the removal of phenol and having highly favorable distribution coefficients.

If recovery is not attractive, it may be possible to use

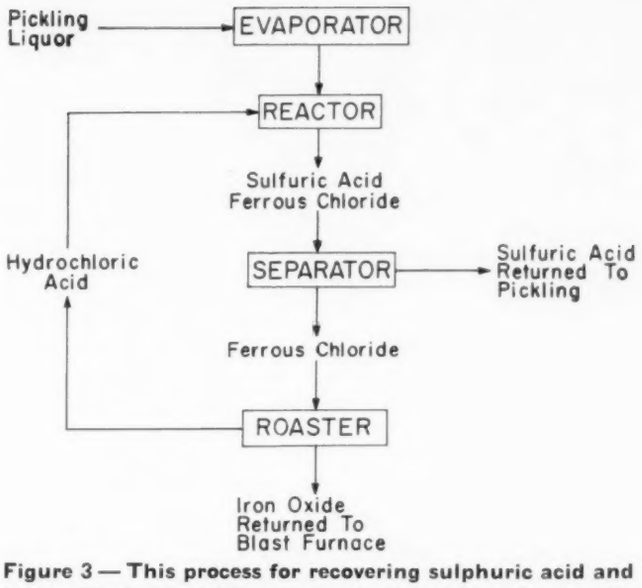


Figure 3 — This process for recovering sulphuric acid and iron oxide from pickling liquor is the object of extensive tests.

the phenol-bearing waste for quenching coke, or to destroy the phenol by either biological or chemical oxidation.

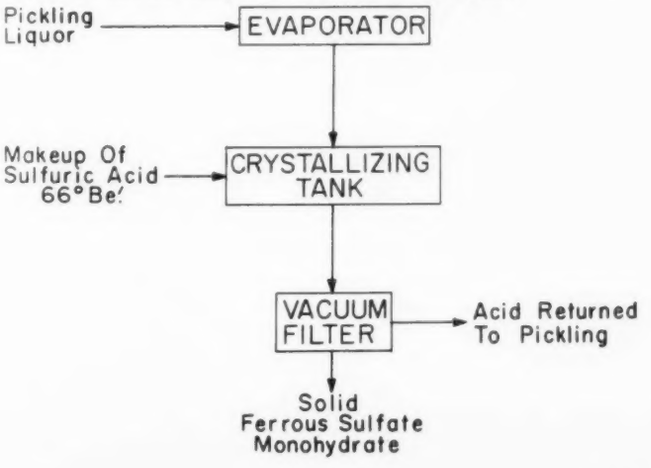
A number of biological treatment plants have operated efficiently. One new way to apply biological oxidation to a waste water containing a relatively small amount of phenol is to introduce it into a recirculating cooling tower system. The tower then becomes the equivalent of a trickling or biological filter. A plant which recently adopted this procedure has reported good reduction of phenol with no difficulties in the recirculating cooling system (13).

Chemical oxidation with chlorine dioxide and chlorine has effectively removed one to two ppm of phenol at a water treatment plant, but higher than theoretical quantities of the oxidizing chemical appear to be necessary.

TREATMENT OF CYANIDE WASTES

Cyanide bearing waste waters are most frequently treated by the alkaline-chlorination method (14). This involves oxidation of the cyanide either to cyanate or to

Figure 4 — Schematic of process for recovery of sulphuric acid and ferrous sulphate from pickling liquor.



nitrogen and carbon dioxide by the use of chlorine or hypochlorite under controlled pH conditions. This destruction reaction proceeds through several stages. When chlorine or hypochlorite reacts with a dilute solution of an alkali cyanide, the first product is cyanogen chloride (CNCl). If the pH is greater than 10.0 there is no further reaction between the chlorine and the cyanogen chloride. The latter hydrolyzes to cyanate. If the pH is less than 10.0, the available chlorine reacts with the cyanate giving nitrogen and carbon dioxide.

The conversion of cyanide to cyanate requires three pounds of chlorine and 3.08 lb of caustic soda per pound of cyanide. Complete destruction of cyanide to carbon dioxide and nitrogen requires 7.4 lb of chlorine and 6.15 lb of caustic soda per pound of cyanide. If the cyanide bearing waste water contains other materials with a chlorine demand, such as ammonia, oils, phenol, etc., the amount of chlorine required per pound of cyanide destroyed may be many times these guidance dosages.

The pH of the reacting solution has considerable influence upon the rate of reaction for the destruction of cyanide. Although the formation of cyanogen chloride is largely independent of pH, the rate at which the cyanogen chloride hydrolyzes to cyanate is retarded at pH values of less than 8.0. The rate of destruction of cyanate to nitrogen and carbon dioxide is most rapid at a pH of less than approximately 9.0.

All the reactions detailed above proceed reasonably well within the pH range of 8.5 to 9.0. Therefore, when a cyanide destruction system is being set up for operation by relatively untrained personnel, especially for batch type operation, the operator is instructed to control the pH within this specified range during the entire destruction reaction.

Since the destruction of cyanide is an oxidation reaction, it has long been felt that this reaction could be monitored and controlled by the oxidation-reduction potential (REDOX) of the system. Figure 5 presents a curve of the oxidation-reduction potential as a function of time during a cyanide destruction reaction. The initial potential in this case was +180 millivolts, although a negative potential has sometimes been observed. Chlorine was added to this solution for the first 96 min at a constant rate so that at the end of the period, sufficient chlorine would have been added to completely destroy the cyanide plus an excess desired to cause the reaction to go to completion. During the initial stages the addition of chlorine caused no change in the oxidation-reduction potential; after approximately 36 min, however, there was a sharp rise, indicating that the cyanide had been converted to cyanogen chloride or cyanate. Since the initial reaction occurs almost instantaneously, the time lag was due more to the rate at which the chlorine was being added to the solution than to the reaction rate of the destruction reaction.

Subsequently the curve gradually slopes upward, indicating a gradually increasing REDOX potential. It is felt that this is due to the additional destruction of the cyanate and the presence of free chlorine. The final leveling off of the REDOX potential curve indicates that sufficient chlorine has been added for complete destruction of the cyanide and that excess free chlorine is available. If the chlorine feed is discontinued, the REDOX potential should not change during the remainder of the destruction reaction. A decrease in potential would indicate that insufficient chlorine had been added to complete the reaction.

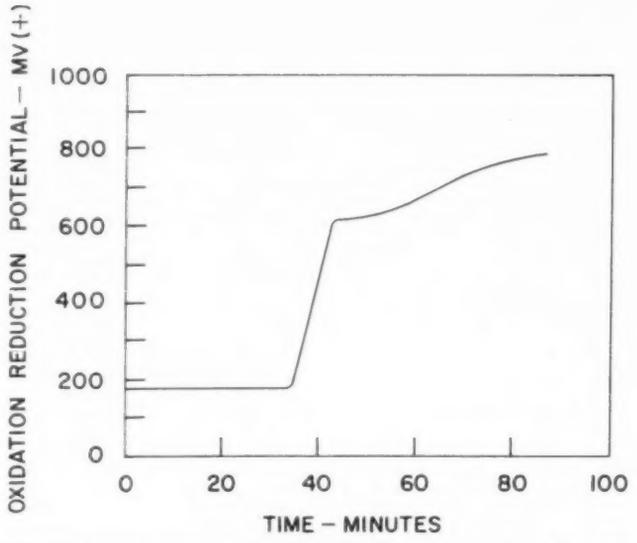


Figure 5 — Change in oxidation-reduction potential with time in the destruction of cyanide by alkaline chlorination.

Time, min	Cyanate, ppm	Remarks
15	7.5	
30	15.1	
45	43.4	
60	35.5	
75	27.6	
96		Chlorine feed discontinued
210	4.2	
330	2.8	

pH during reaction was maintained between 8.5 to 8.9.
Free chlorine residual after 96 min was greater than 50 ppm.
Free chlorine residual after 330 min was 12.5 ppm.

Figure 5 suggests that automatic proportioning of chlorine or hypochlorite as a function of the cyanide content of the influent can be accomplished by monitoring of the reaction. We have had close liaison with two industrial plants which are presently using oxidation-reduction potentials to monitor and control their cyanide destruction reactions.

One plant is utilizing REDOX potential for control of a batch operation in which the holding tank is filled with the waste before the destruction reaction is initiated. During the period that one tank is being filled, a second tank is being treated. The method used for the treatment in this plant is to start the feed of chlorine and of caustic. The chlorine feed is maintained at a constant value, and the caustic feed is adjusted so as to hold the pH within the desired range of 8.5–9.0. When the first plateau is observed on the recording REDOX meter, this indicates that the cyanide has been converted to cyanate. The chlorine feed is continued until the REDOX potential reaches and holds a maximum for a period of approximately 30 min. After 30 min, the free chlorine residual is titrated with an amperometric titrator. Once it has been confirmed that a free chlorine residual is being maintained in the destruction tanks, the chlorine feed is discontinued, and the tank is allowed to

agitate for approximately 60 min. During this 60-min period there is no substantial reduction in the REDOX potential. The tank is then discharged to waste.

A second plant with which we have been closely associated is using oxidation-reduction potential to control the feed of sodium hypochlorite to a continuous system in which the cyanide-bearing waste is transferred by pumps to a holding tank where the pH is adjusted to 9.0. The waste then overflows to a second tank which is the destruction tank. Sodium hypochlorite is added to the destruction tank based on REDOX monitoring. The controls are set at present so that chlorine is fed until a positive potential of +350 millivolts is registered. It has been determined that this potential guarantees the conversion of the cyanide to cyanate, but there is some question as to whether complete destruction of the cyanate to carbon dioxide and nitrogen is being accomplished.

This brings up the question of whether it is only necessary to convert the cyanide to cyanate or whether complete destruction to carbon dioxide and nitrogen is required.

It is a generally accepted fact that cyanate is 1/1000 as toxic as cyanide. The big uncertainty has been whether it would be possible for cyanate to be reduced, producing cyanide in the receiving waterway. The data tabulated in Figure 6 indicate that the stability of cyanate is a function of the pH (15). There is a thermodynamic possibility that cyanate could be reduced to the cyanide ion, if either anaerobic bacterial action or sunlight provided the energy theoretically required. Laboratory studies have shown, however, that neither anaerobic bacterial activity nor ultraviolet light caused the reduction of the cyanate to the cyanide ion.

Studies have been conducted on the effect of cyanide on the operation of sewage treatment plants (15). It appears that one or two ppm of cyanide in association with normally encountered heavy metals interfered initially with nitrification, but the treatment plant regained its efficiency in about one week. On the basis of these studies it was concluded that a sewage treatment plant utilizing trickling filters for secondary treatment could handle an influent with one ppm of HCN.

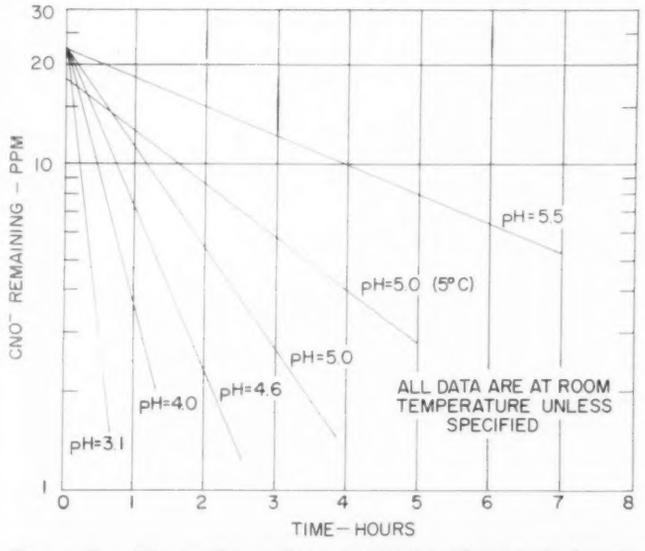


Figure 6 — Chart shows decomposition of cyanate ion in buffered acid solutions.

A PLANT POLICY ON WATER

The situation which industry faces is not a shortage of water but rather the necessity for re-use, with maintenance or improvement of the quality of the water available. Since the ultimate consumer of the products of industry must pay the price for all conditioning of water, society demands that waste waters be treated in the most economical manner, that is, at their point of origin. This objective can be attained throughout industry, if all managements realize the scope of the problem.

A practical start can be made in any plant if management will place the over-all water program in the hands of a person with responsibility and authority to develop and administer policies regarding water usage and waste water treatment. Much more than merely collecting data is involved. With the production and utility departments, he must work out the actual needs for water, with respect to both quantity and quality, in each operation. Using the help of specialists where needed, he must arrive at the optimum—not necessarily the most perfect—method of handling each pollution problem with respect to the actual conditions in the specific plant. And he must maintain continuing control of water in the plant as it grows and changes, year after year, attempting to understand and anticipate the evolving philosophy (16) which will govern the use of "industry's most important raw material."

BIBLIOGRAPHY

1. "Estimated Use of Water in the United States, 1955," by K. A. MacKichan, Geological Survey Circular 398 (1957); J. Am. Water Works Assoc., vol. 49, pp 369–91 (1957).
2. Mill and Factory, vol. 60, no. 5, pp 81–5 (1957).
3. "Magnitude of Industrial Demand for Process Water," by S. T. Powell and H. E. Bacon, J. Am. Water Works Assoc., vol. 42, pp 777–85 (1950).
4. "Symposium on Waste Disposal at a Steel Plant": "General Problems," by R. Nebolsine, Separate No. 492; "Treatment of Sheet and Tin Mill Wastes," by H. MacDougall, Separate No. 493; "Treatment of Flue Dust Wastes," by A. D. Henderson and J. J Baffa, Separate No. 494; "Treatment of Sewage," by J. J. Baffa, Separate No. 495, Proc. Am. Soc. Civil Eng. 80 (1954).
5. "Industry's Water Problems and Their Solution," by H. I. Riegel, 1957 Proceedings, AISE.
6. Panel Discussion on Stream Pollution: "Industrial Wastes in General," by H. A. Reda, Proc. 15th Annual Water Conference, pp 25–9 (1954).
7. "Waste Disposal: Solution to New Problems," The Iron Age, vol. 178, no. 3, p 115 (1956).
8. "Treatment and Re-Use of Mill Scale Wastes," by G. R. Pettit, 1957 Proceedings, AISE.
9. "Evaluation of a Waste Pickle Liquor Treatment," by T. F. Barnhart, 1955 Proceedings, AISE.
10. "Waste Pickle Liquor Disposal," by G. A. Howell, Sewage and Industrial Wastes, vol. 29, pp 1278–81 (1957). "Steel Mill and Coke By-Product Wastes," by W. W. Hodge, Proc. 15th Annual Water Conference, pp 33–48 (1954).
11. "The Dollars and Sense of Pickle Liquor Treatment," by James J. Joseph and E. T. Culver, Iron and Steel Engineer, p 112, March 1958.
12. "Electrolytic Treatment of Waste Sulfate Pickle Liquor Using Anion Exchange Membranes," by C. Horner, A. G. Winger, G. W. Bodamer, and R. Kunin, Industrial and Engineering Chemistry, vol. 47, no. 6, p 1121 (1955).
13. "Biological Oxidation of Oil Refinery Wastes in Cooling Tower Systems," by H. F. Elkin, E. F. Mohler, Jr., and L. R. Kummick, Sewage and Industrial Wastes, vol. 28, no. 12, p 1475 (1956).
14. "Technology of Treating Plating Wastes," by N. S. Chamberlain, H. B. Snyder, Jr., Proceedings 10th Industrial Waste Conference, Purdue University (1955), pp 277–305.
15. "Behavior of Cyanates in Polluted Water," by J. D. Resnick, W. A. Moore, and M. B. Ettinger, Industrial and Engineering Chemistry, vol. 50, no. 1, p 71 (1958).
16. "Water Pollution Abatement Research in the Steel Industry," by C. A. Bishop, Sewage and Industrial Wastes, vol. 29, pp 1273–7 (1957). ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Friday, December 12, 1958
Christmas Dinner and Dance
Social Hour 6:30 P.M.
Dinner 7:30 P.M.
Dancing 9:00 P.M. until 12 M.
Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Saturday, December 6, 1958
Christmas Dinner and Dance 7:30 P.M.
Golden Ballroom, Hotel Statler, Buffalo, N. Y.

CHICAGO SECTION

Saturday, December 6, 1958
Christmas Dinner and Dance
Dinner 7:30 P.M.
Main Ballroom, Sherman Hotel, Chicago, Ill.

CANTON SECTION, CLEVELAND SECTION AND YOUNGSTOWN SECTION

Saturday, December 6, 1958
Christmas Dinner and Dance
Dinner 7:00 P.M.
Cleveland Engineering & Scientific Center,
3100 Chester Avenue, Cleveland, Ohio

DETROIT SECTION

Saturday, December 6, 1958
Christmas Dinner and Dance
Dinner 7:30 P.M.
Dancing 9:00 P.M.
Social Hour
Detroit Yacht Club, Belle Isle, Detroit, Mich.

LOS ANGELES SECTION

Saturday, December 13, 1958
Christmas Dinner and Dance
Pacific Room, Statler Hotel, Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, December 6, 1958—Dinner 6:00 P.M.,
Meeting 7:00 P.M.

"Modern Design of Slab Reheating Furnaces," by H. C. Henschen, Special Engineer, Fuel Dept., Bethlehem Steel Co., Sparrows Point, Md.

"Maintenance Organization and Training," by C. F. McClurg, Assistant Division Superintendent, Maintenance & Utilities, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Saturday, December 13, 1958
Christmas Dinner and Dance
Dinner 8:00 P.M.
Dance 9:30 P.M.
Penn-Sheraton Hotel, Pittsburgh, Pa.

ST. LOUIS SECTION

Saturday, December 13, 1958
Christmas Dinner and Dance
Social Hour 7:00 P.M., Dinner 8:00 P.M.
Dancing 9:00 P.M. to 1:00 A.M.
Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Saturday, December 13, 1958
Christmas Party
Mt. Diablo Country Club, Danville, Calif.

UTAH SECTION

Friday, December 5, 1958
Christmas Party
Salt Lake City Country Club, Salt Lake City, Utah

TEN TIPS To Better Scarfing

by Stanley Shatuck, Service Engineer,
National Cylinder Gas Div., Chemetron Corp., Chicago, Ill.

THESE ten commandments for better scarfing are born of mill and dock experience in both the Pittsburgh and Chicago areas.

The list is particularly useful for training new men, but it includes points all too frequently overlooked by veteran scarfers.

1. Purge properly. Open and close the fuel gas and the oxygen preheat valves alternately for 10 or 15 sec. This should be sufficient to purge a 50-ft length of hose.

2. Be sure the starting rod is properly located and fed at the right rate. One gets the best start if the end of the rod is slightly off center with respect to the cutting orifice and $\frac{3}{8}$-in. off the end of the tip. Molten rod metal should not blow away above the surface of the bloom, slab or ingot. Starting rod feeds should be at least $\frac{1}{4}$ to $\frac{7}{16}$ in. per stroke.

3. The NCG-recommended starting technique is to fuse the rod for a few seconds before hitting the main cutting oxygen lever; start to preheat with the torch head at a steep angle of 30 degrees to the work and then drop this angle to 5 to 10 degrees simultaneously with the opening of the cutting-oxygen flow. The angle of incidence between the planes of the torch and line of travel should be about 10 degrees in both the starting and running positions. If one learns to move forward while scarfing one can use shorter torches, see where you are going, and prevent foot burns.

4. Shut off the oxygen immediately in the event of a backfire. It takes an old hand to spot all backfires instantly, because torches will often operate after backfiring. Visual observation of the flames and alertness to a whistle are the best clues. In some scarfing operations, backfires can happen once or twice a day. After each one, check the tip nut for tightness, and also purge the torch.

5. Keep enough torches on hand so that each operator can have one of his own and be responsible for its maintenance. Give each torch a spot-check after every shift. By giving each man his own torch, torch life is often increased 100 per cent, good maintenance becomes automatic, and total equipment costs are greatly reduced.

6. Use as many large torches as possible. A big torch will turn out more work per day with fewer passes and wider scarfs. Two-thirds of the torches should be of the larger sizes and of the 3-hose design. With the 3-hose design the operator does not have to be an "artist" to get an easy start, as he always has a stable preheat. To avoid the problems resulting from increased line pressure, repipe the dock if under capacity, rather than boost the line pressure.

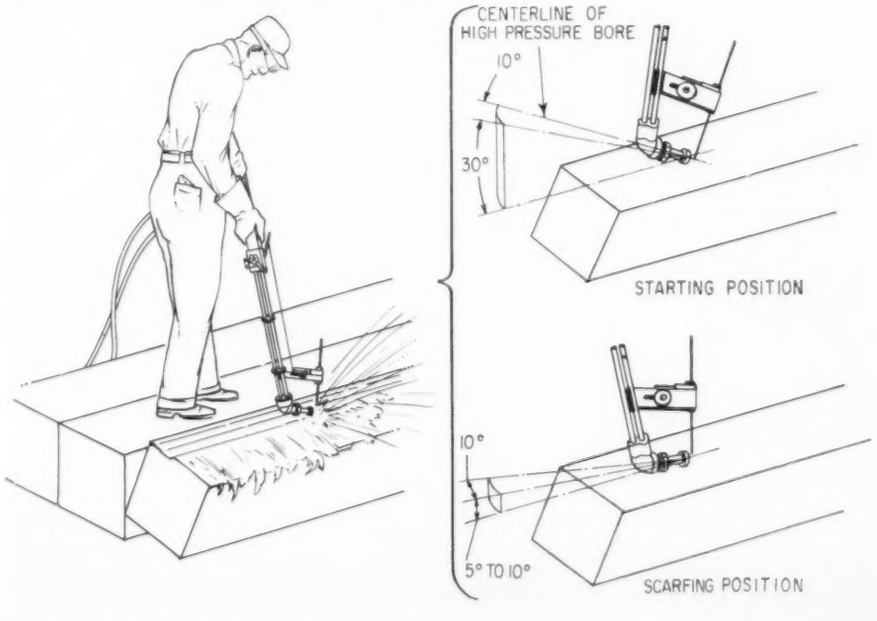
7. Lay out the scarfing dock so that the hoses trail behind the operators. Even so, operators will have to be trained to think of the hose position before they start each pass, to avoid dragging the hoses over hot work or blasting molten metal at them.

8. Keep starting rods stored and protected from the weather. Do not break a bundle and leave the rods on the dock. Corrosion on the rod surface will foul up the wire-feed mechanism.

9. Rotate the tips in the torch head frequently, to get the most out of their wear rings. An average life of five to six weeks for a tip ring is excellent. The hard-surfaced head guard (or wear pad) may last six months. It should be replaced in time to protect the torch head. All operators seem to insist on using the head guard to sweep slag away by short pushes and pulls, but they should be encouraged to do the bulk of their slag removal with a proper scraper.

10. Be sure the bloom, ingot or slab is either steeply tilted or supported in the diamond position—so that molten metal and slag runs away from the scarf. A popular technique with blooms and ingots is to make the first scarf on a corner, work forward, make a corner scarf at each major turn, and thus end without a final fin on the scarfed work. ▲

Figure 1 — Torch position is important.



Submerged Arc Welding Helps Steel Plant Maintenance

by James Angus, General Foreman
Welding Shop, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

Flat and circular build-ups are accomplished in reduced time . . . . annealing furnace covers are welded inside and out by boom arrangement . . . . longitudinal seams on heavy crane girder run in two passes with negligible distortion . . . . such jobs call for equipment flexibility.

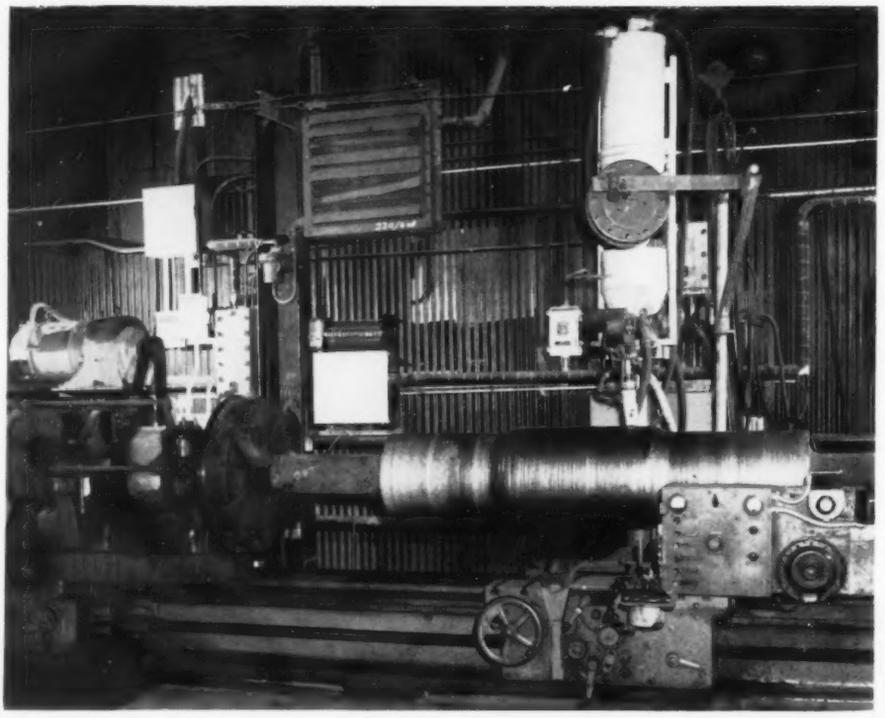
FLEXIBILITY, dependability and speed are at least three requisites of the well organized steel mill maintenance shop. In their attainment, arc welding has provided major assistance—for quick repair jobs, hardsurfacing for impact and wear resistance, build-up of worn parts and the fabrication of structural and equipment components. Advent of automatic and semi-automatic submerged arc welding techniques, and, more recently, agglomerated alloy fluxes, have furnished valuable tools to expedite this class of work.

There is nothing new about this, you may say. That is substantially true, but the fact is that the successful application of automatic or mechanized welding calls for a good deal more than just the investment in welding heads, controls, electrode wire and fluxes. The key is the setup, the fixturing and positioning. That is where the maintenance and welding engineers are put to the test. A setup must be adaptable to one job today, to another tomorrow, and without the expense and delay of major revisions.

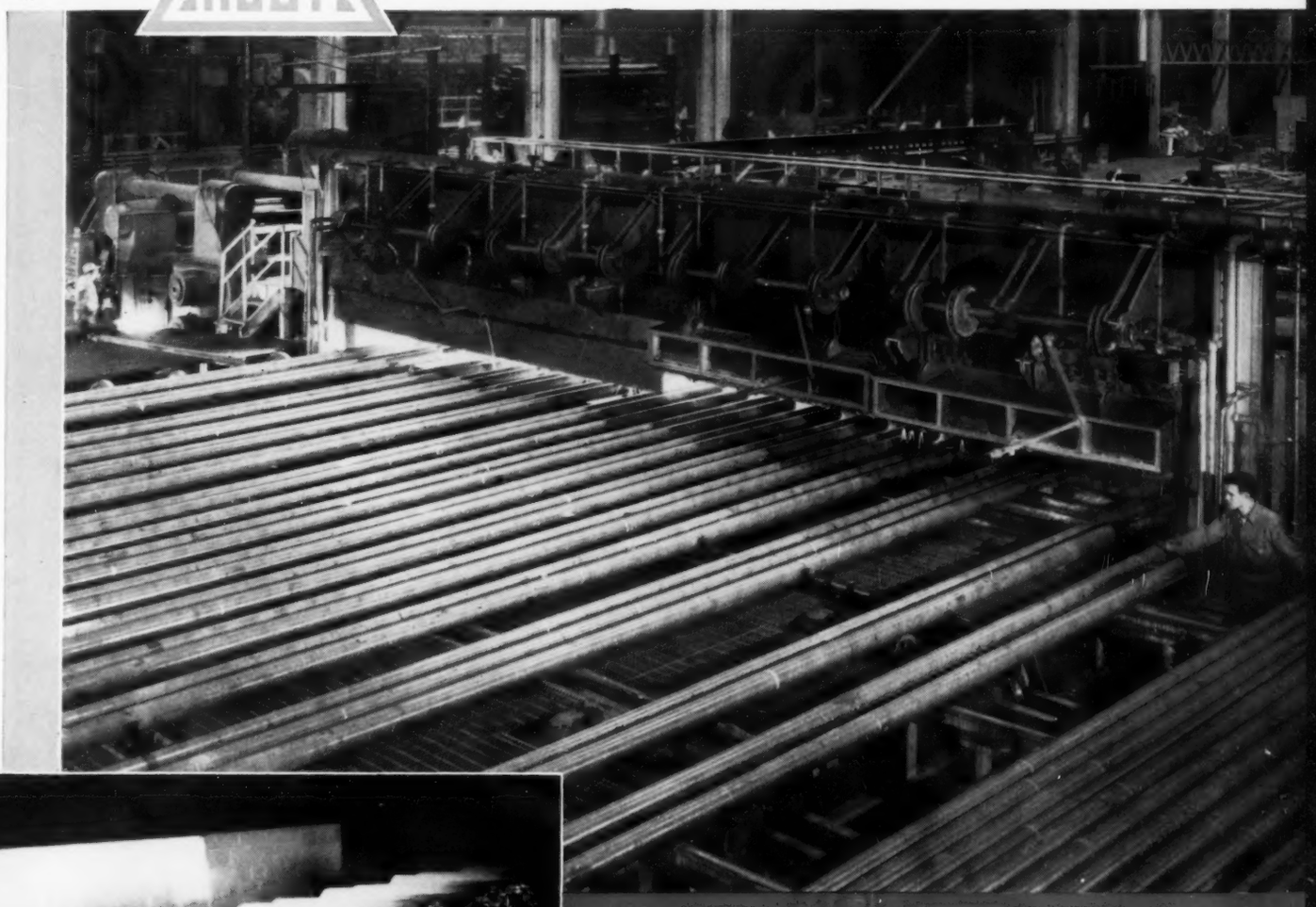
A sampling of typical installations at Weirton will show how we have approached the assignment. First, consider surface build-ups. Mill rolls are, ofcourse, a No. 1 project. The 40-in. blooming mill feed roll, shown in Figure 1, is an example. It has over-all length of 8 ft-22 in. diam work surface and 18-in. journals. Here it is set up in a lathe which mounts a Lincoln LAF-2 automatic welding head on the carriage, controls conveniently at the front and at low level. The tailstock is loaded by a weight and lever system, not shown, so that it can come and go with expansion and contraction of the roll to avoid being snapped off.

Lathe centers have been raised to increase swing capacity. Carriage drive is independent of the faceplate drive to give greater equipment flexibility, such as for longitudinal or flat surface build-ups, circumferential build-ups and seams, pipe fabrication, etc.

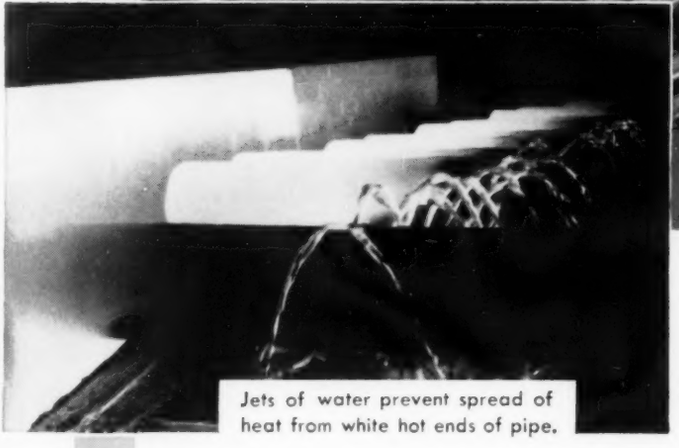
Figure 1 — Feed roll for 40-in. blooming mill, with 22-in. diam work area and 18-in. journals, 8 ft long, is mounted in a lathe for automatic submerged arc build-up with alloy steel wire. Preheat burner is behind the roll.



New RUST UPSETTER FURNACE takes 3½" to 10¾" pipe



Upsetter Furnace at Seamless Specialty Mill, Jones & Laughlin Steel Corp., Aliquippa, Pa.



Jets of water prevent spread of heat from white hot ends of pipe.

A new slot type Upsetter Furnace for heating pipe ends prior to upset forging was especially designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation's Aliquippa seamless tube mill. It is the first upset furnace of its type and handles a variety of sizes of seamless tubing from 3½" to 10¾" in diameter. The pipe is used for deep wells.

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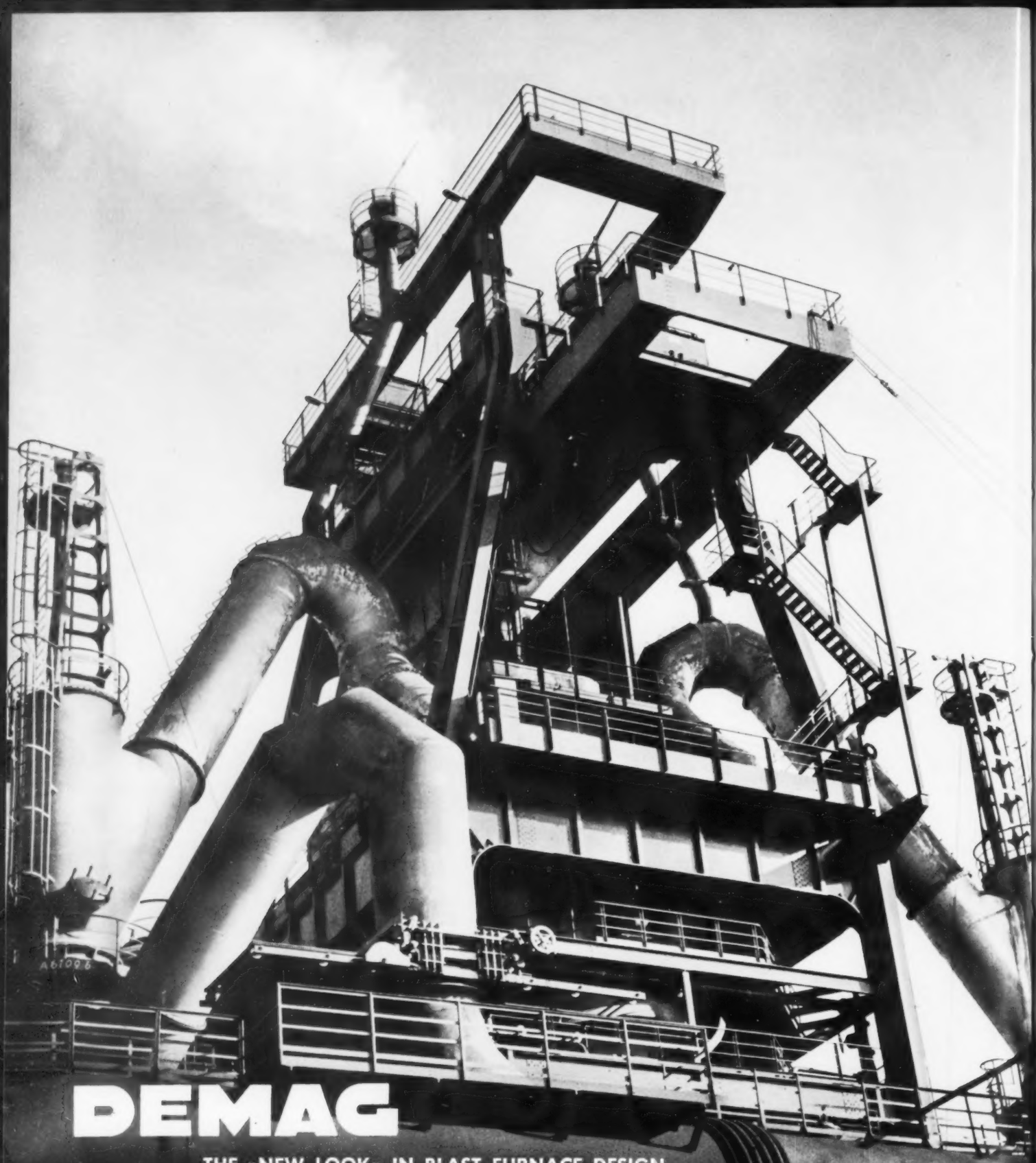

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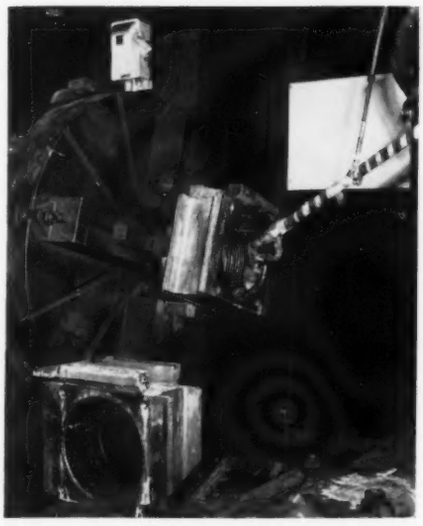


Figure 2 — Nozzle extension from semi-automatic welding head on lathe carriage deposits a build-up inside this journal box in one-sixth the time required for a manually applied overlay. In operation, a plate is fastened over the edge of the bore to contain welding flux.

In this instance, roll surfacing is with SAE 6150 (chrome-vanadium) steel wire, using a neutral granular flux of the Lincoln 840 type. This hard deposit, it has been found, will give service life of ten to one over the original roll surface. By newer techniques, making use of specially compounded alloy flux, it is possible to obtain similar physical characteristics, with only mild steel electrode wire.

It is essential in this type of work to introduce preheat to the roll before applying the weld metal. Practice calls for 300 F for rolls with 0.30 per cent carbon and an additional 100 F for every ten points more carbon. Heat is applied by a row of small flames from a longitudinal pipe set close to the roll and behind it. Holes $\frac{3}{16}$ in. diam and two in. apart are drilled along the pipe, making a burner which is supplied a suitable mixture of coke oven gas and air to produce the desired preheat or interpass temperature. A sheet steel deflector is mounted on the frame of the carriage to prevent burner flames from contacting the roll in the immediate area of metal deposition. This avoids the necessity of making any adjustments in the burner while build-up is in progress. Speed variation on the roll is from 22.4 to 75 sec per revolution.

Internal build-ups on such parts as journal boxes for diesel buck locomotives are processed by the novel arrangement shown in Figure 2. A nozzle extension from a Lincoln ML-2 "Squirt" welder is positioned to direct a continuous deposit of weld metal on the inner surface while the box turns in the face plate of a lathe. A screw feed on the carriage supporting the welding head gives a uniform spiral build-up.

In operation, a small plate is attached to the outer face of the box, with an opening in it to accommodate the nozzle, but extending over the edge of the bore sufficiently to contain the flux inside and to facilitate build-up to the extreme edges. Once the electrode arm is positioned, a cupful of flux is poured inside the bore and the arc is started at 400 amp and 30 arc volts. As the part turns, the flux tumbles down continuously to the bottom to envelop the arc.

Electrode wire is $\frac{5}{64}$-in. diam mild steel, Lincoln L-60, with neutral granular flux, Lincoln 840. As the build-up progresses, one or two small additions of flux may be needed. The job is handled in about one-sixth the time required for a manual surfacing, while the quality and uniformity of the deposit result is machining taking less than half the time involved in finishing manually applied overlays.

Hardsurfacing and flat build-ups are common in equipment maintenance. A representative flat build-up, on a blooming mill cradle arm finger, is illustrated in Figure 3. It is unusual in that an oscillating attachment (Lincoln Spreadarc) was used on the automatic welding head to give a bead two inches wide, thus laying down considerably more weld metal per inch of travel and per pass. The area was worn down 1.75 in., so a 2-in. overlay was applied to a width of about 13 in., for finishing to 12 in. Length of each pass was only about 14 in., so the wider bead was particularly advantageous. Current setting was 800 amp at 30 arc volts.

Mechanized welding is ideally suited to many varieties of cylindrical and tank-type assemblies, such as the inner covers for strip coil annealing furnaces shown in Figure 4. These covers are produced in both

Figure 3 — Flat build-up, 2 in. thick, is applied to this worn cradle arm finger for a blooming mill, using mechanized submerged arc welding with an oscillating attachment on the electrode to give a bead 2 in. wide and, thus, increase operating factor.

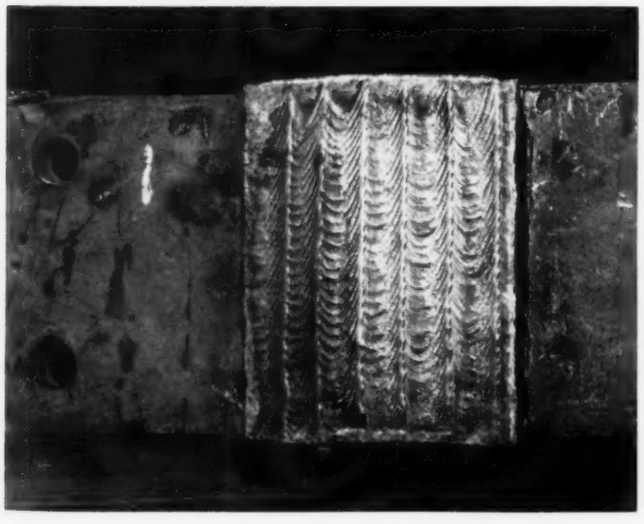
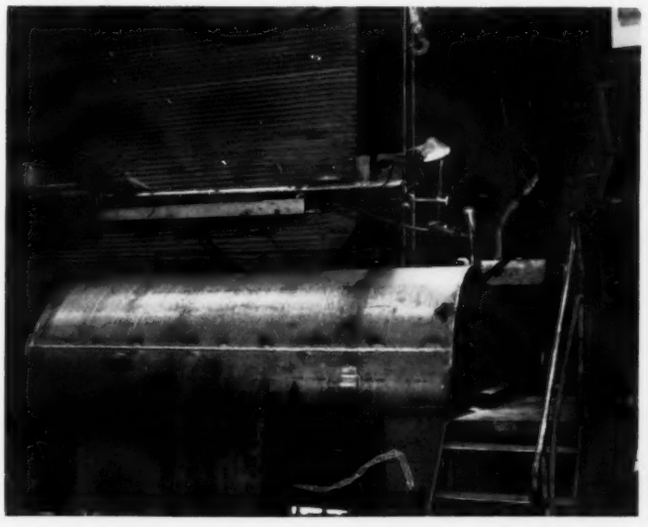


Figure 4 — Double-course inner cover for annealing furnace is 160 in. long and is easily welded, inside and out, longitudinally and round its 56-in. diam. Extension boom carrying welding gun has 20-ft reach, 12-ft height adjustment.



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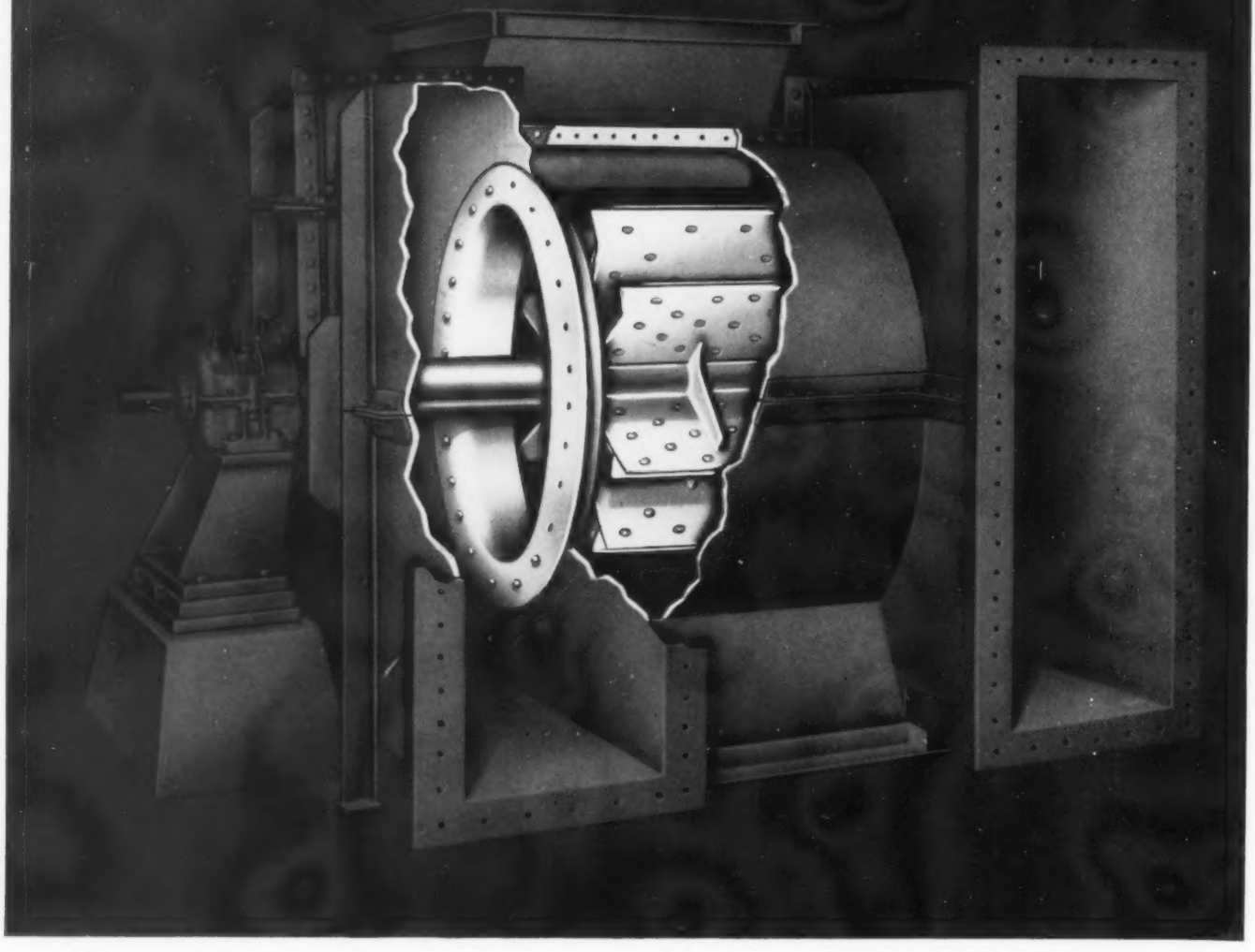

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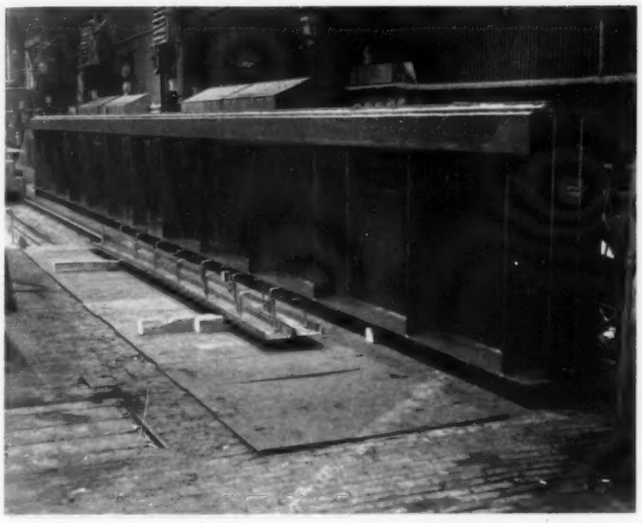


Figure 5 — All-welded crane girder is 58 ft-9½ in. long, 5 ft deep, with 24-in. flanges. Longitudinal welds between web, flanges and angles are made in two passes, the piece being turned over after each pass for an opposite fillet, to minimize distortion.

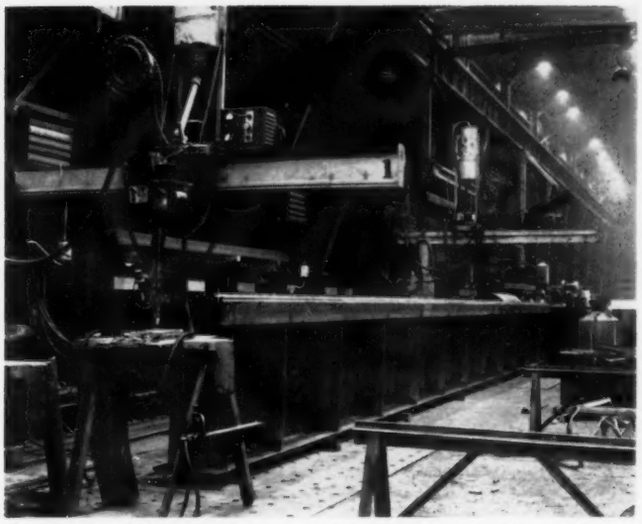


Figure 6 — Two automatic and mechanized welding heads were used on longitudinal seams. They were equipped with extra long jaws to reach down into lower flange-to-web joints while the beam was positioned at 45-degree angle. Welding speeds were 24 in. per min on first pass, 12 in. per min on second.

single and double course designs, the former 118 in. long, the latter 160 in., both 56 in. in diameter and of $\frac{5}{16}$-in. plate. They have been welded up in both mild steel and 19-9 stainless steel on the setup illustrated, requiring only a change in electrode wire. Preliminary fabrication includes roll forming and manual tack welding.

Specially designed by Weirton engineers, the welding equipment is unique, comprising a box-section boom with an extension pipe arm to provide a reach of 20 ft from the carriage support post at the left, along with a height adjustment of 12 ft. The welding head is the semi-automatic ML-2 type, being mounted with its flux cone on a gas-cutting torch body, permitting three dimensional adjustment. It may be traversed longitudinally at speeds of 4 to 60 in. per min.

Seams in these covers must be gas tight, with 100 per cent penetration and no porosity. About a 10 per cent sampling of production welds is made for nick-and-break tests on both lengthwise and 'roundabout seams. The units are welded with an inside pass at 400 amp, 30 arc volts and speed of 20 in. per min, straight polarity. The outside pass is at 450 amp, 31 arc volts and 12 in. per min, positive polarity. Rotation for circumferential seams is provided by powered rollers on which the cylinder rests.

Flux is a neutral granular, Lincoln 840. A vacuum recovery system is mounted on the carriage, with sufficient length of exhaust hose to reach the furthest point of boom extension.

Among the major structural weldments fabricated by Weirton is the 100-ton crane girder, 58 ft-9½ in. long shown in Figure 5. It comprises 47 pieces of flame-cut plate ranging in thickness from $\frac{3}{4}$ to $1\frac{1}{4}$ in. Web plate is 1-in. stock, 5 ft in depth, made in three butt welded sections. The two top flange plates are of 1.25-in. material, 24 and 18 in. wide, respectively, and also of three butt welded lengths. Splices are staggered, so that one will not be directly above another. To the undersides of the wider top flange are welded 8 x 6 x 1-in. angle rails. Lower flanges are of 1-in. plate, 24 and 12 in. wide, respectively. Stiffener plates, 13 on a side, are of 1-in. plate, 11 in. wide and relieved at the inner corners to clear web-to-flange welds. Stiffeners are welded on both sides all the way around.

It will be appreciated that a considerable footage of longitudinal welding was involved—between the sandwiched flange plates, angles and along the web. These welds were all $\frac{5}{16}$-in. fillets, each pass made by a pair of automatic welding heads mounted on cantilevered booms supported on carriages, the latter riding on tracks, as will be noted in Figure 6, total weld depending on thickness of plates and how used.

A "sinker" pass was made at 600 amp, 30 arc volts, 24 in. per min, the finish pass at 700 amp, 36 volts and 12 in. per min.

The welding heads were fitted with elongated jaws to reach down into the lower web-to-flange joints as shown, while the beam was positioned at a 45-degree angle. Practice was to make one longitudinal pass, turn the beam over and run an opposite fillet; then turn again for the second pass. This held distortion to a minimum, even dispensing with the need for hold-down bolts which had originally been thought necessary to "bow" the assembly down while welding.

Oscillating mechanisms also are fitted to these welding heads to permit their application to wide-bead build-ups, another example of flexibility in equipment planning.

Other diversified applications for automatic welding developed at Weirton include the fabrication of skewback channels for open-hearth furnaces. These are 20-in., 176-lb channels, requiring the attachment of a 3-in. heavy wall pipe along one flange at its extremity. Continuous welds were 50 ft long, made at 600 amp, 29 volts and 16 in. per min.

Skid pipe for structural mill furnaces also is a regular production task. It is an assembly of a 1-in., half-round tangentially and lengthwise to a 3-in. extra heavy pipe, with welds on each side under the flat face of the half-round. These sections have been welded at 500 amp, 30 volts and 24 in. per min in lengths up to 20 ft. ▲

Figure 1 — Jones & Laughlin stainless and strip division at Louisville, Ohio, the nation's newest source for stainless steel sheets, is now in full production.

Louisville, Ohio, Plant of J&L

THE nation's newest source of stainless steel sheet and strip is now in full operation at Louisville, Ohio. All of the facilities are in production at the new $17,000,000 stainless and strip division plant of Jones & Laughlin Steel Corp.

The plant, located in this town of 4500, seven miles east of Canton, O., has an annual capacity of 36,000 tons of flat-rolled stainless steel, and employs about 250 people. Inventories of finished stainless sheet and strip in coils and cut lengths are being maintained to assure immediate deliveries to customers.

Flat rolled stainless is a new product for J&L's stainless and strip division, which, at its Detroit plant, produces stainless, alloy and carbon steel ingots, slabs, billets, bars and wire, and at Youngstown, Ohio, and Indianapolis, Ind., restricted specification strip steels.

The completion of the Louisville plant means still further diversification of products for Jones & Laughlin, the nation's fourth largest steel producer. J&L's entry into the stainless steel business was effected in 1957 when the assets and business of the Rotary Electric Steel Co., Detroit, were transferred to J&L. A strip steel division was formed that same year when the assets and business of the Cold Metal Products Co., Youngstown, were transferred to J&L.

The Louisville plant is located on a 140-acre tract of land along the tracks of the Pennsylvania Railroad's Chicago-New York main line. It also is readily accessible to the main highway shipping routes. The buildings contain 330,000 square feet of operating space in rebuilt and new buildings on the site of the old Superior Sheet Steel Co.

The principal equipment of the Louisville plant includes a 52-in. cluster-type (Sendzimir) cold rolling mill which incorporates the latest engineering design for precision rolling and quality control of stainless flat-rolled products.

One of the innovations on this mill is a crown adjustment which makes it possible to maintain an extremely accurate gage along the entire width of coils.

The mill is capable of rolling stainless steel sheets in thicknesses ranging from $\frac{3}{16}$ down to 0.003 in.

The Wean Engineering Co., Inc. of Warren, Ohio, installed eleven of the stainless processing lines.

The first line in the flow of material is a coil conditioning and build-up line for 400 grade series, straight chromium stainless steels. The line incorporates a two-head, three-prong type uncoiler to handle coils with inside diameters from 17 to 30 in. A butt welder is used for joining the coils, and a post-anneal is incorporated to anneal the welds prior to box annealing the coils. This line can also be used as a recoil and inspection line.

Hot rolled coils of the 300 grade chrome nickel series are processed on the continuous hot rolled annealing and pickling line. This line is equipped with a butt welder for coil build-up to 20,000 lb maximum on

Figure 2 — Material flow chart at Louisville, Ohio, plant, Jones & Laughlin Steel Corp.

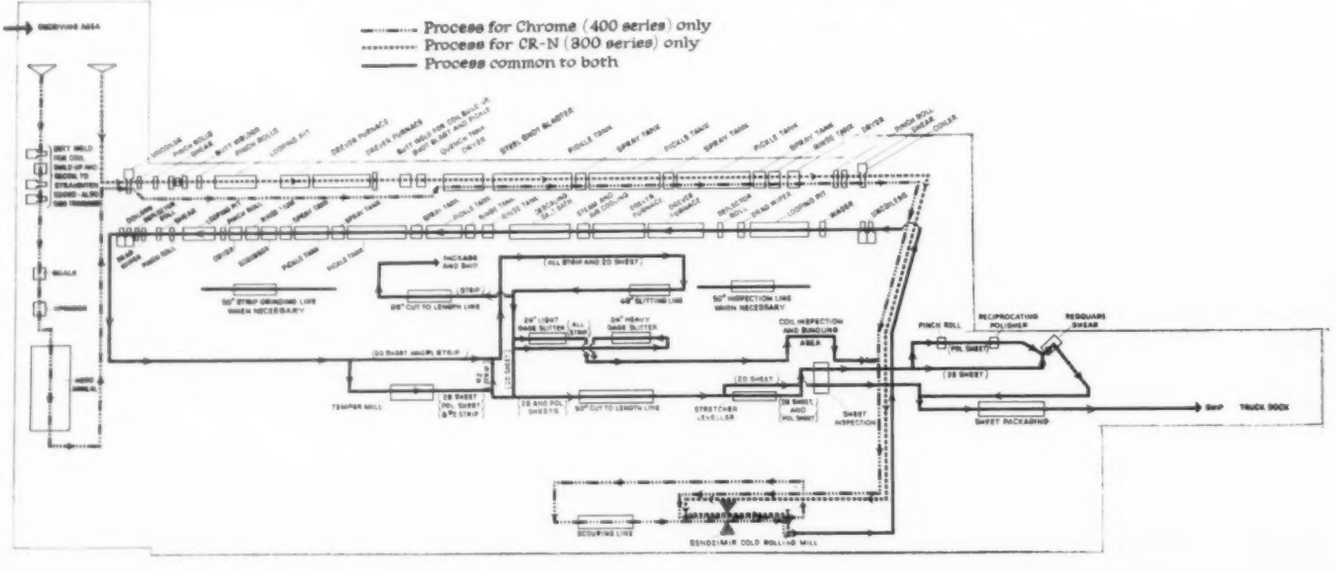


Figure 3 — The 52-in. cold reducing mill is capable of reducing the gage of stainless steel from $^{3}/_{16}$ down to 0.003 in.

Figure 4 — Stainless steel is handled with the utmost care. The plant features the latest equipment in the processing of quality stainless sheet and strip in coils and cut lengths.

Is Ready For Full Operation

60-in. outside diameter. The entry end has a 50-ft deep pit for loop storage to feed the line during the welding operation. The welded strip then passes through the annealing furnace, a Pangborn Rotoblast, three separate pickling tanks (each followed by a rinse tank) and a dryer. The strip is then rewound on a mandrel type recoiler.

The coils, up to 52 in. wide, are then cold reduced on a Sendzimir mill to finished heavy gages or intermediate gages which will undergo further reduction later.

The coils are then taken to the cold rolled annealing and pickling line. This line has two uncoilers and two recoilers and deep storage pits at both the entry and exit end to permit the line equipment to operate at maximum capacity without interruption. In this line, the strip passes through a stainless steel annealing furnace, a descaling salt bath, an electrolytic pickling tank, a nitri-hydrofluoric pickling tank and a second electrolytic pickling tank (each followed by a rinse tank), a scrubber and rinse tank, and a dryer.

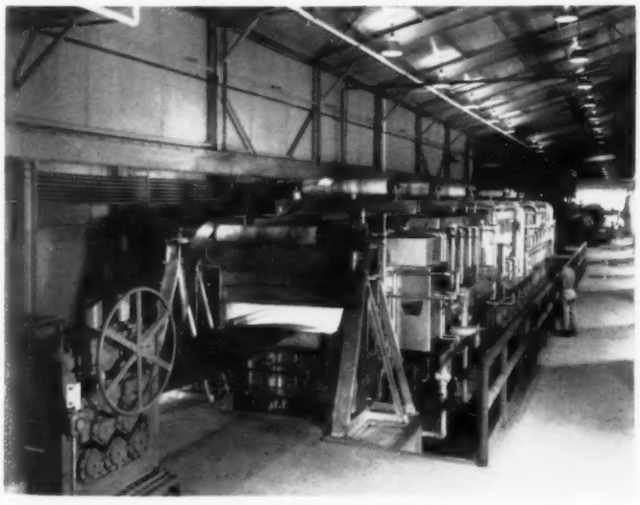
The coils which have been reduced to intermediate gages are then returned to the Sendzimir mill for final reduction. Then they are sent back for a second pass on the cold rolled annealing and pickling line prior to final processing.

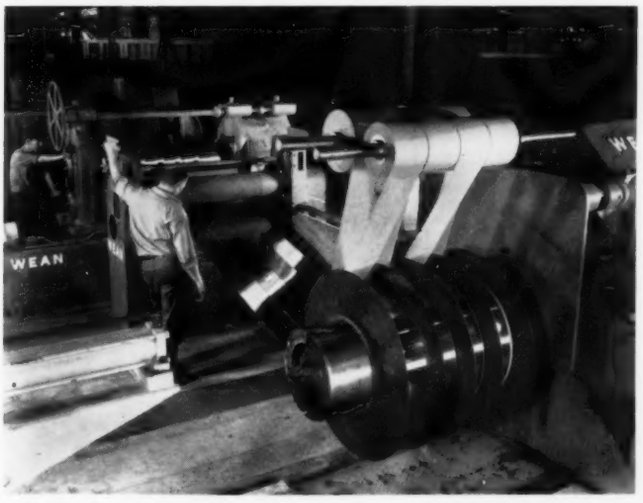
The coils can then be sent either to the 54-in. temper mill for additional work hardening of the surface, or to the 52-in. cut-to-length line. Sheets from this upcut shear line are then stretcher leveled and polished on surface grinders as required.

The coils from the temper mill are sent to the 52-in. slitting and side trimming line. The narrow coils from this line can be further reduced in width on one of the two 24-in. slitting lines. Slit coils from 6 to 24 in. in width can then be cut-to-length on the flying shear line, or built into coils of specific weight on the inspection line.

There are two lines for intermediate processing where required. A scouring line and a surface grinding line. All of the lines have been designed with consideration for the high quality surface requirements of stainless steel consumers. ▲

Figure 5 (left) — Versatility of the continuous anneal and pickle line for processing hot rolled material is shown as a coil for the "300" series stainless is fed into the furnace, while another coil for the "400," or straight chrome series, is passed over the top of the furnace. The "300" series is annealed and pickled in this continuous operation. The "400" series is annealed in hood-type furnaces, and only pickled on this line. Figure 6 (right) — The new Jones & Laughlin stainless and strip division plant ships both coils and sheets of the many types of stainless. A three-man crew operates the 50-in. slitting line, one of the many finishing operations which are performed at the new mill.





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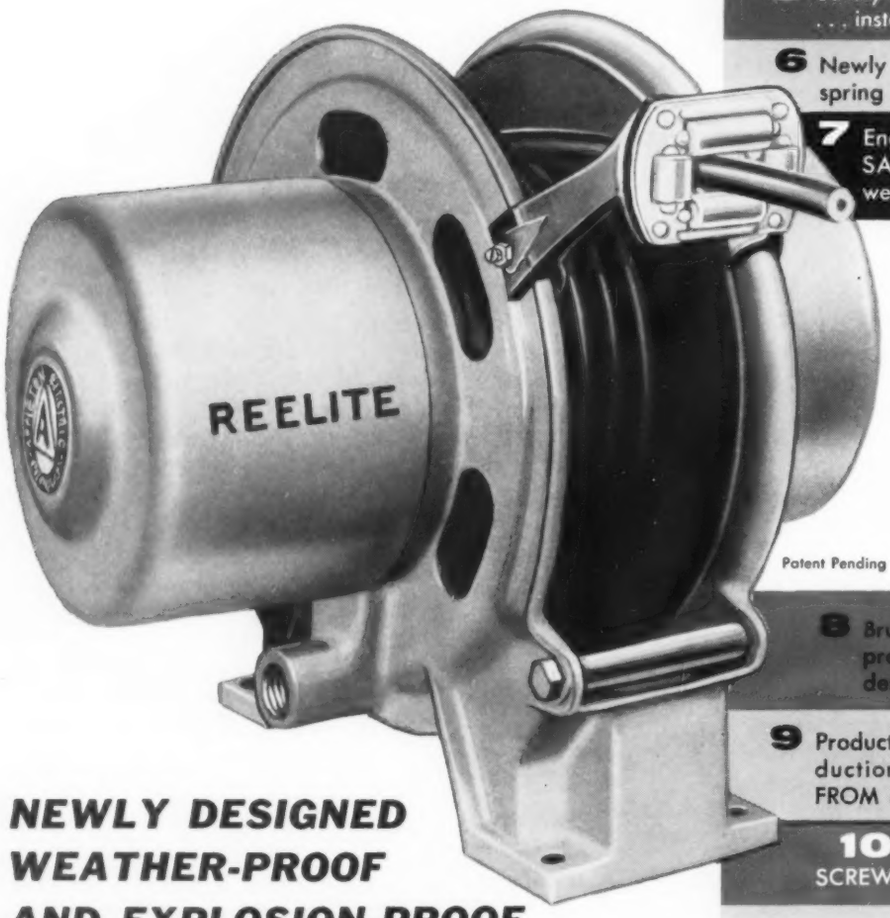

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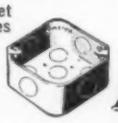

Outlet Boxes

Industrial Lighting Equipment

High Strength Steel Is Produced In Wide Sheets

FOR use in rocket motors, Lukens Steel Co. has succeeded in rolling what is believed to be the widest sheet of high-strength steel ever produced. The sheet was produced as part of a development program in so-called "second generation" rocket motors using solid fuels.

The sheet measures 160 in. wide—about one-third wider than the widest sheet hitherto produced by the "pack-rolling method" and almost twice as wide as material produced by commercial sheet mills.

The key facility required for production of the sheet was Lukens' 206-in. plate mill, largest in the nation. No other existing rolling facility is able to provide sheet wider than about 140 in.

The pack-rolling process puts layers of high-strength material between two steel cover plates to form a sandwich. By welding the resulting "pack" all around, the high-strength alloys are protected during the heating and rolling cycles in a controlled atmosphere. This permits production control of decarburization and oxidation and results in a smooth sheet surface.

Figure 1 — Sheet, measuring 160 in. wide and 192 in. long, is the prototype of high-strength wide sheets designed to form cylindrical housings for solid-fuel rocket motors.

The pack-rolling process also permits a sheet to be cross-rolled, a technique not normally possible on commercial sheet mills. By sending the pack "lengthwise and sidewise" in a series of passes through plate mill rolls, the sheet displays more nearly identical transverse and longitudinal properties.

In the development project resulting in the widest sheet ever produced, the product was sonically measured using Vidigage techniques. Readings were taken at 1-foot intervals over the entire surface of the sheet, whose final dimensions were 160 in. wide and 192 in. long. The thickness readings varied from 0.082 to 0.088-in. with no significant crown anywhere.

Pack-rolled wide sheet is of interest to rocket-motor designers for two reasons:

1. It reduces the number of weld seams required for a given motor casing—thereby reducing the hazard of premature motor failure.
2. Material may be produced to closer gage and crown tolerances than that now generally available—offering more precise weight control.

These factors plus the superior properties obtainable through cross-rolling account for the potentialities of the pack-rolling of sheet material for missiles and rocket engine applications. Lukens is also working on the production of close-tolerance, sheet-gage heads required for high-performance rocket engine casings. ▲

Figure 1 — Shovel is designed to withstand the heat from the open furnace long enough to do its job.

Heat Resistant Loader Banks Furnace Door

A GRANITE City (Ill.) steel producer relies on a fast-moving, heat-resistant tractor shovel to bank the doors of its seven open hearth furnaces with dolomite. With furnace temperatures close to 3000 F, the banking operation must be rapid to protect personnel and equipment from the heat.

The Granite City Steel Co.—a producer of hot and cold-rolled sheets, light plates, galvanized and tinplate, and other flat-rolled products—charges each of its furnaces about every 11 hours. To protect the inside furnace lining, a bucket load (about 16 cu ft) of raw dolomite is used to bank each furnace door. The high temperatures inside the open hearth furnaces necessitate a fast operation. In addition, before Granite City Steel brought out its tractor shovel, the furnace temperature dropped somewhat when a door was held open several minutes to allow time to hand-shovel the dolomite.

Trouble theoretically ended with the purchase of a "Michigan" Model 12B Tractor Shovel, made of heat-resistant steel and with its fuel tank safely in the rear. Hydraulic controls make it fast-operating. Torque converter and power-shift transmission means no foot-clutching is necessary to change speed or direction. And the operator wears a welder's mask to guard his face and eyes from the blinding heat.

But the tractor shovel needed another safeguard. The heat made the hydraulic fluid bubble and foam through the hydraulic system. Bucket tilt and bucket arms worked sluggishly. Mr. Owen Davis, superintendent of maintenance, open hearth and blooming mill departments, recognized the trouble immediately. He switched to Tydraul Oil 150, a fluid that works effectively at temperatures of 450 F. With the tractor shovel poking into the furnaces to unload the dolomite, the temperature of the machine may momentarily rise a couple hundred degrees—but not enough to affect this hydraulic fluid.

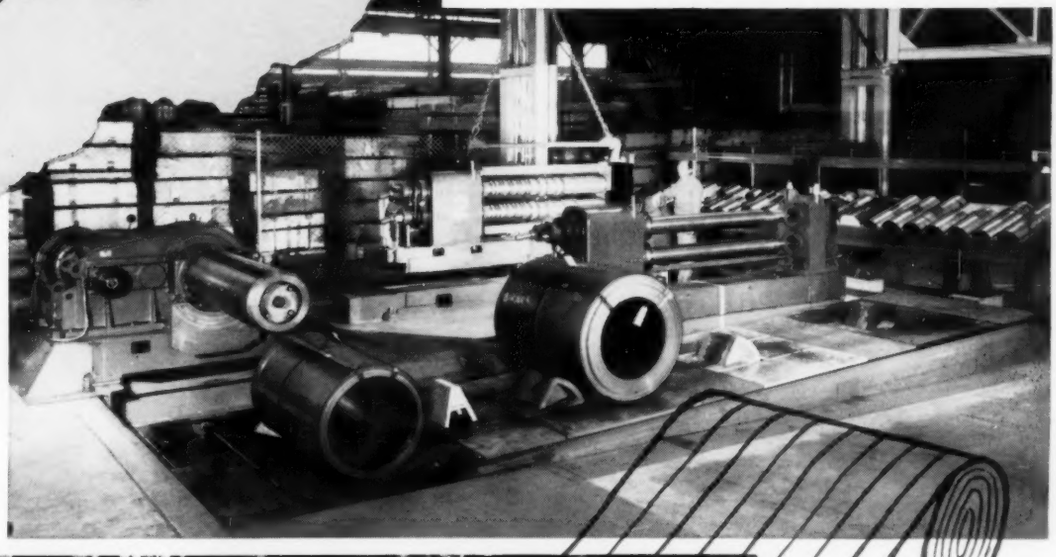
The tractor shovel also lifts and positions a ¾-in. steel plate, measuring 5 x 7 ft, across each door of the open hearth furnaces just before they are charged. A hook, bolted to the bucket, lifts the plate which is kept in place across the furnace opening, except when flushing the furnaces (that is, when removing some of the impurities from the bath of molten metal inside).

The tractor shovel also cleans up debris on the charging floor and handles double-burnt dolomite, fluorspar and open-hearth slag, when necessary. ▲

Step Up Production with Stamco Coiling Lines

Stamco Slitting and Coiling Lines will step up your production because they are designed to meet your particular specifications. Years of experience have led to the development of equipment that will meet every slitting and coiling requirement. Stamco slitting and coiling lines are now efficiently handling coils from 500 to 60,000 pounds and are designed to give dependable, maintenance-free service.

Write us, stating your requirements . . . we'll gladly give complete details—no obligation.

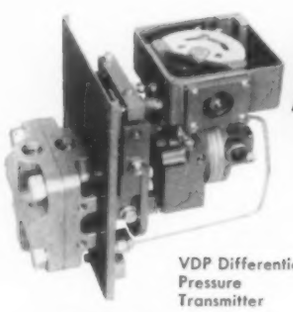


View shows coil and traverse, coil pay off reel, coil loading ramp and detachable slitter head.

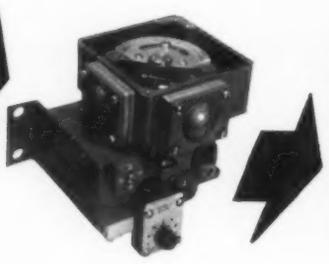
Overall view of coiling line from entrance end.

LAY YOUR SHEARING PROBLEMS AT STAMCO'S DOOR

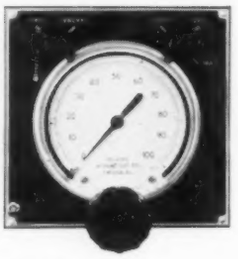
STAMCO, Inc., New Bremen, Ohio



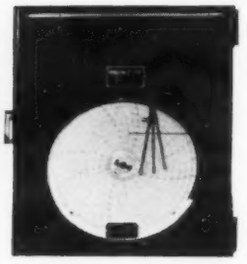
VDP Differential Pressure Transmitter



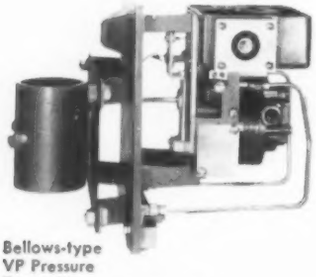
VC Controller



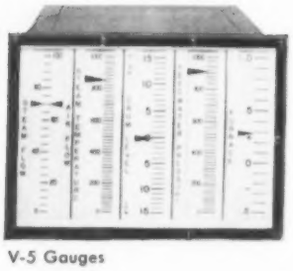
Type "A" Control Station



Flow, Pressure and Temperature Recorder



Bellows-type VP Pressure Transmitter



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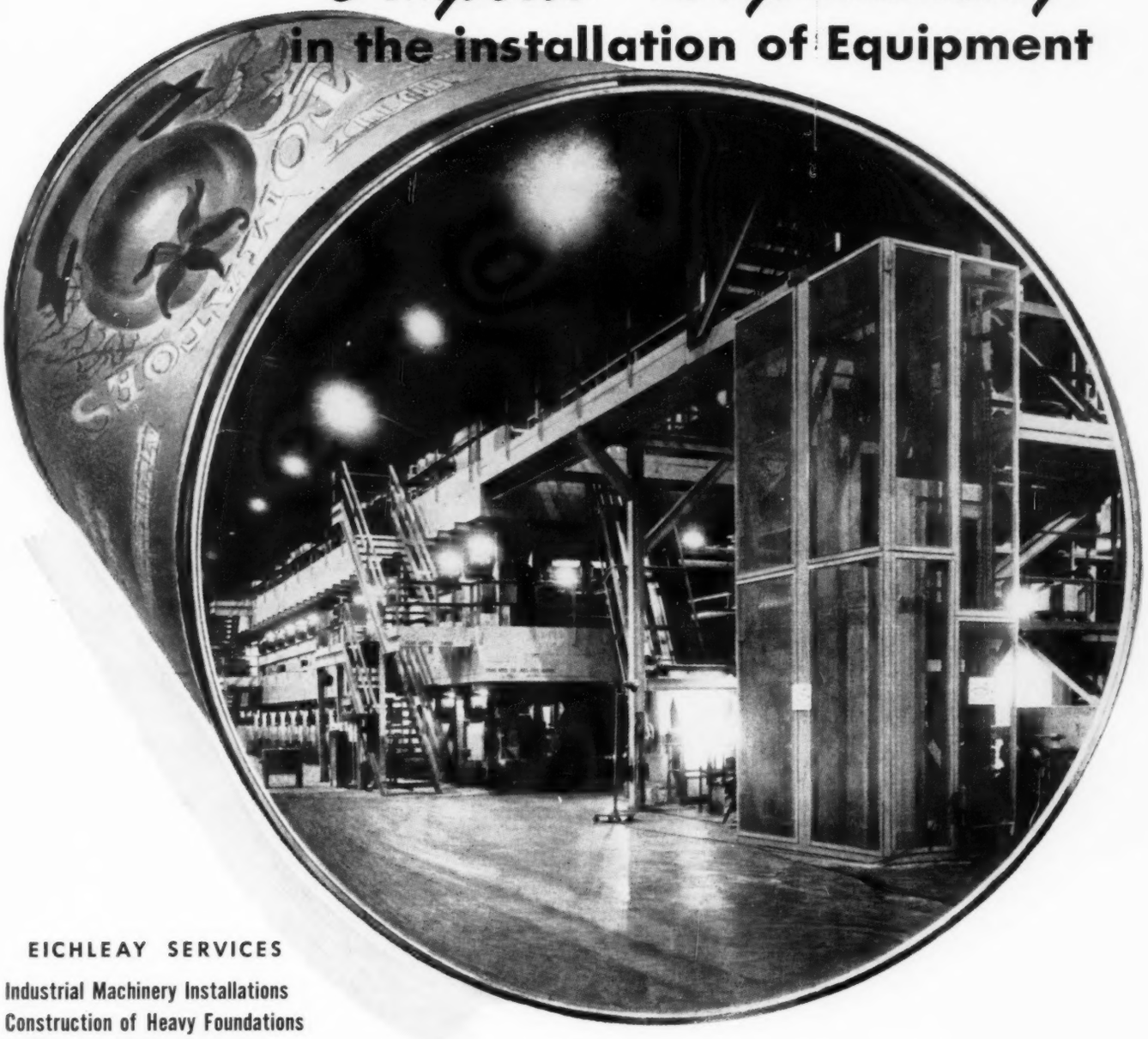

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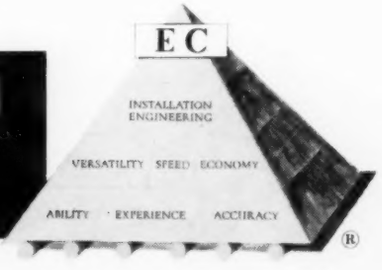

Coal Chemical Plant Modernization . . .

Light oil plant facilities shown below at the River Rouge plant of the Ford Motor Company, built in 1918, were recently replaced by the Wilputte Coke Oven Division of The Allied Chemical Corporation. The modernized plant now has a capacity to process 45,000 gallons wash oil per hour.

Features of this design are:

Modern, Efficient Distillation Results in Improved Recovery

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Centralized Controls Permit Minimum Attendance

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Arrangement Provides for Safety and Accessibility

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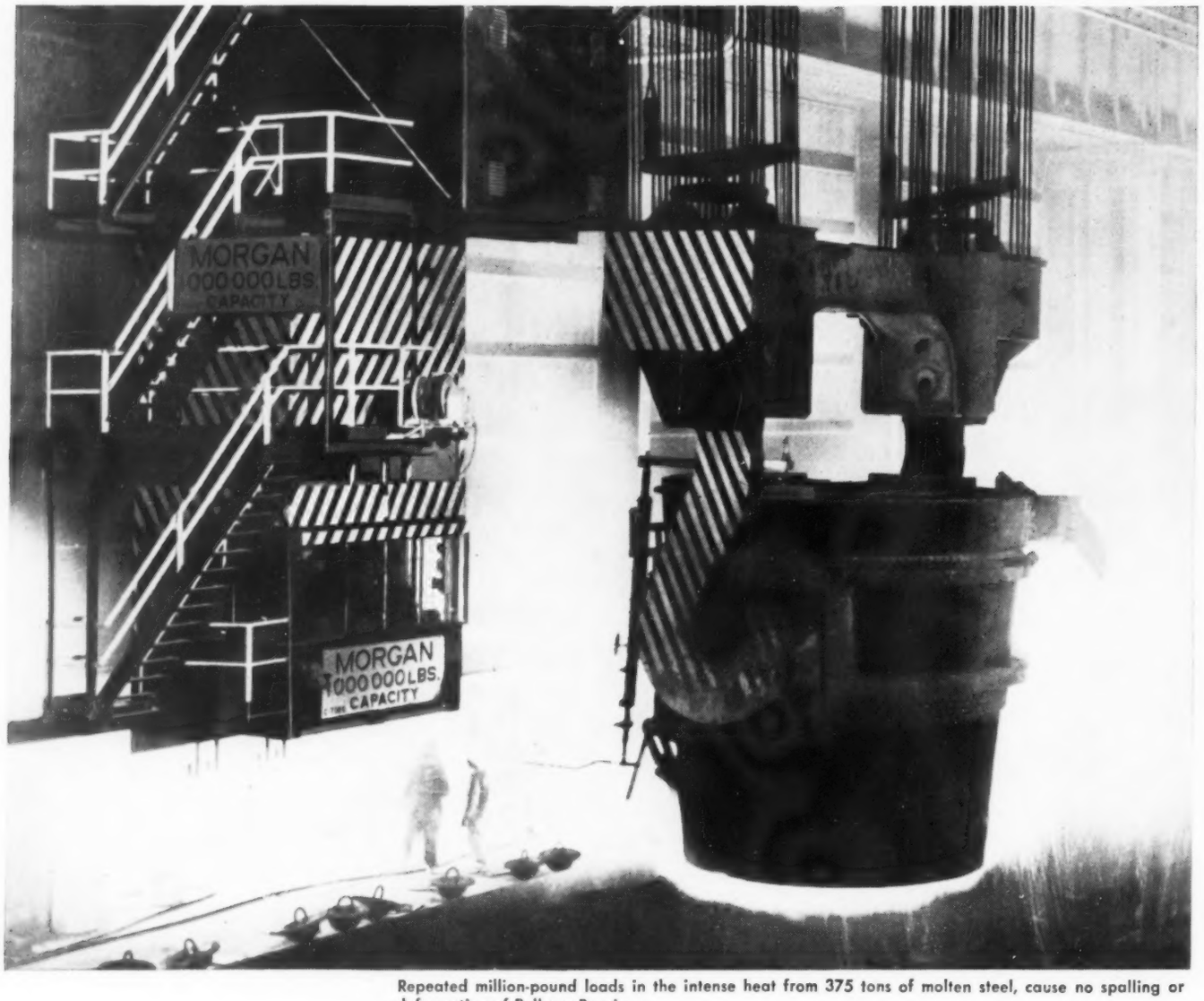

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The maximum-type bearings in the hoisting sheaves are mounted directly on the shaft without inner races, which greatly simplifies assembly for applications of this size.

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Sheaves ready for assembly on shaft and installation in lifting beam.

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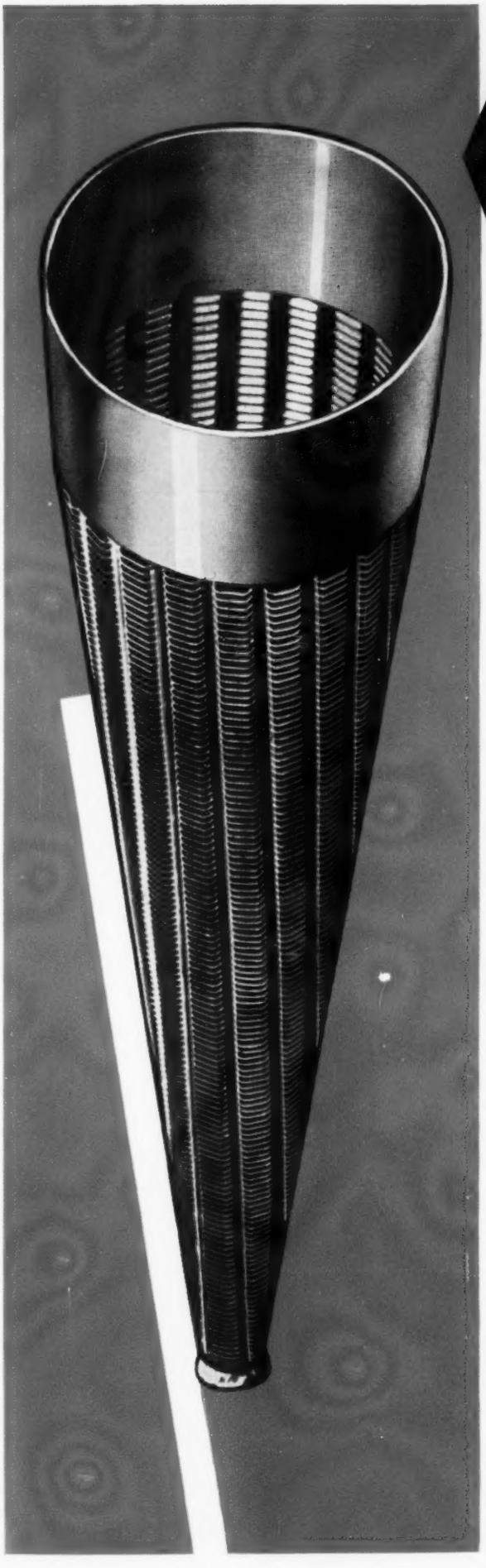

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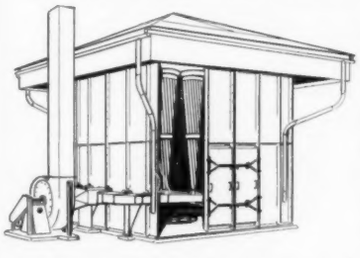

You will find this wear-reducing story of interest. A word to Green will bring you the details.

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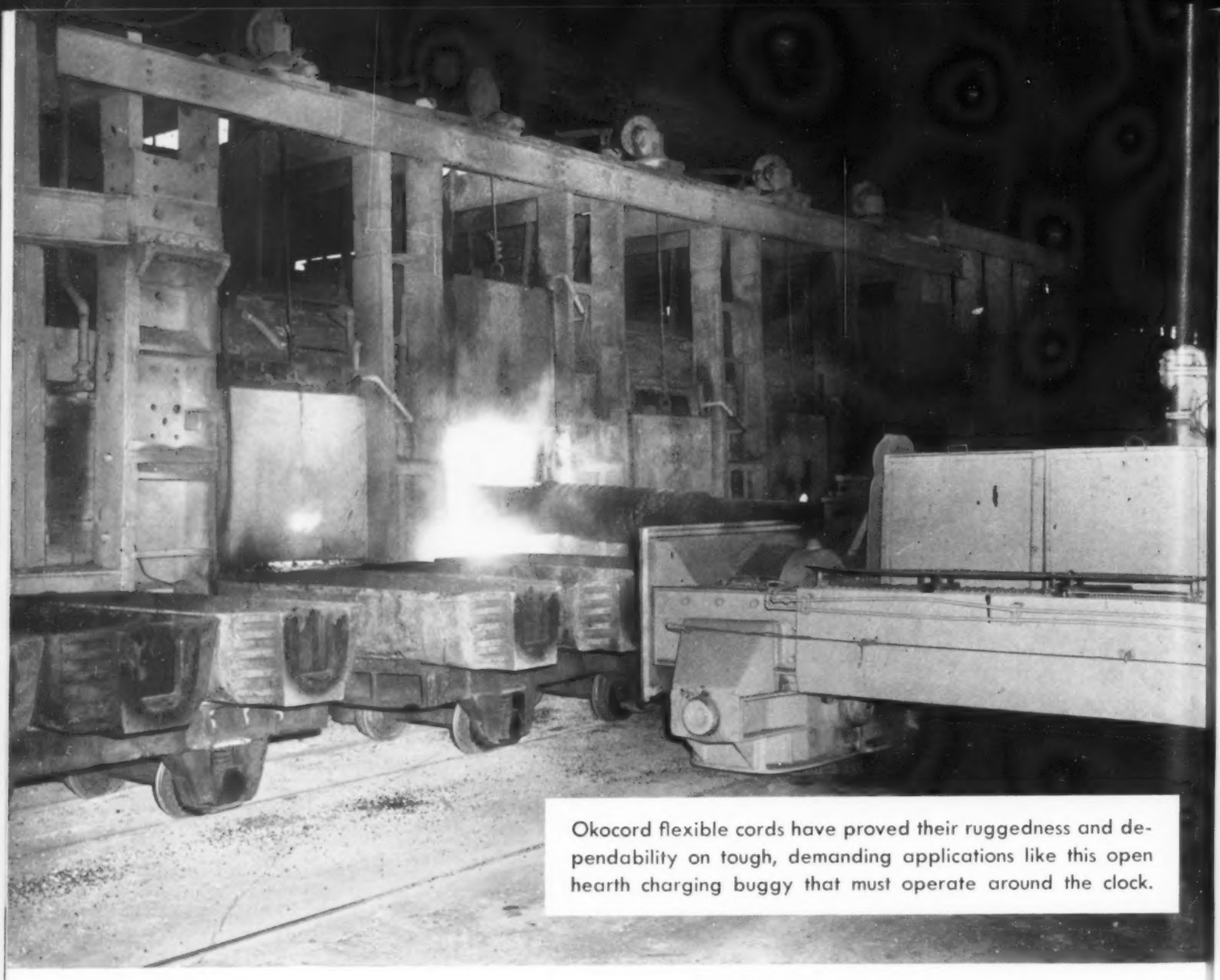

Okocord flexible cords have proved their ruggedness and dependability on tough, demanding applications like this open hearth charging buggy that must operate around the clock.

Heat and abuse . . . no problem for Okocord portable cables

The charging machine above is controlled by Okocord flexible cables. They have to withstand constant heat and abrasion. And they're wound and unwound about a small reel every time the charging arm enters the furnace—literally hundreds of times every day.

Okocords are used for tough applications like this because they've been proved in service in steel mills . . . and in every other kind of plant. The rugged Okoprene sheath has superior flame resistance . . . plus the tire-tread toughness and extra flexibility that come from being cured in a continuous metal mold. The Okocord conductors have maximum flexibility because they are made of fine copper wires twisted together with a short lay.

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4903

Date-line Diary...

October 1

Δ Florida Steel Corp. is making a secondary offering of 74,925 shares at $13.625 per share. Shares represent a part of the holdings of certain selling shareholders who will continue to own a total of 198,150 shares or 18.56 per cent of the total common stock outstanding.

Δ Electro Metallurgical Co., Div. of Union Carbide Corp., announces a new type of chromium carbide, identified as Type "M," which can be supplied in tonnage quantities, at prices for powder of $2.60 per lb for tonnage quantities, and $3.00 per lb, in smaller quantities, f.o.b. Niagara Falls, N. Y. Purity ranges from 98.9 to 99.9 per cent.

October 2

Δ No. 1 industrial bundles of steel scrap in the Chicago district dropped $6.50, to $44.00 a ton.

October 3

Δ Prices of copper, lead and zinc were increased ½¢ each; lead was marked up to 12¢ a lb, zinc to 10½¢, and copper to 27¢ a lb.

Δ Government figures showed that construction expenditures for the 9-month period ended September 30 reached $36,400,000,000 compared with $35,900,000,000 in the same period of 1957.

October 6

Δ Custom smelters in the U. S. increased price of copper ½¢ to 26½¢ a lb.

Δ The AISI reports that the operating rate of the steel industry for the week of October 6 is scheduled at 1,918,000 tons (71.1 per cent of capacity). This compares with 1,901,000 tons one week ago (70.4 per cent capacity) and 2,105,000 tons one year ago. Index of production for the week is 119.4.

October 7

Δ The American Iron Ore Assn. reported that September shipments from Northern lake ports, both U. S. and Canadian, were 8,705,886 gross tons compared with 11,828,076 in September, 1957.

Δ The AISI reports that shipments of finished steel products during August, 1958 totaled 4,835,023 net tons, compared with 4,081,744 net tons in July, 1958 and 6,229,853 in August, 1957.

Δ The Bureau of Mines reported that production of Pennsylvania anthracite for September, 1958, was 2,073,000 net tons compared with 1,779,000 in August, 1958 and 2,173,000 tons in September, 1957.

October 8

Δ General Motors and International Union of Electrical Workers agreed on a contract involving some 25,000 GM employees in Ohio, Illinois, New York and New Jersey. The pact follows the pattern set by settlement between UAW and GM.

Δ Eastern railroads' net income for the first eight months of 1958 amounted to $35,000,000, compared with $174,000,000 earned in the same period of 1957, but shows a marked increase from the $27,000,000 deficit at the end of the first six months of 1958.

October 10

Δ The AISI reports that steel output for September, 1958 amounted to 7,611,000 net tons compared with 7,286,003 tons in August, 1958 and 8,977,906 tons during September, 1957; production for the first nine months of 1958 totaled 59,069,895 compared with 87,704,075 tons for that period of 1957.

Δ Loadings of rail freight cars last week amounted to 677,016 cars, highest since early November, 1957.

Δ The United Steelworkers of America A.F.L.-C.I.O. International assumed control of Local 2869 representing about 6000 production workers at Kaiser Steel Co. plant at Fontana, Calif., resulting from an investigation of the local's affairs by a commission appointed by USW president, David McDonald.

October 13

Δ Federal agencies reported that unemployment in the month ended September 15 declined 600,000 reducing the jobless total to 4,100,000, the lowest in the year of 1958.

Δ Two major producers advanced their quotation on copper 1¢ to 27½¢ per lb.

Δ The AISI reports that the operating rate of the steel industry for the week of October 13 is scheduled at 1,987,000 tons (73.6 per cent of capacity). This compares with 1,933,000 tons one week ago (71.6 per cent capacity) and 2,070,000 tons one year ago. Index of production for the week is 123.7.

October 14

Δ National production of goods and services jumped to a yearly rate of $440,000,000,000 in the third quarter of 1958, compared with $429,000,000,000 in the second quarter of 1958, and $445,600,000,000 in the third quarter of 1957.

Δ A uniform price of 27½¢ per lb has been established by Anaconda Co. following the one-cent advance announced previously by Phelps Dodge and Kennecott.

October 15

Δ Price of lead increased ½¢ per lb to 13¢ in New York.

Δ U. S. Dept. of the Interior, Bureau of Mines, reports that marketed production of natural gas, second quarter 1958, totaled 2,546,900,000,000 cu ft, slightly below last year.

Δ General Electric Co. report for the third quarter of 1958, sales $1,003,621,000, net earnings $58,589,000, compared with the third quarter of 1957, sales $1,047,966,000, earnings $55,165,000; and for nine months ended September 30, 1958 sales totaled $2,982,615,000, earnings $161,970,000, equal to $1.85 per share, and in the same period of 1957, sales were $3,169,276,000, earnings $182,988,000, or $2.10 per share.

October 16

Δ Federal Reserve Board increased stock margin requirements to 90 per cent from the 70 per cent in effect.

Δ Price of copper was increased 1¢ to 28½¢ per lb by custom smelters.

Δ The Commerce Dept. reported personal income in September rose to a seasonally adjusted annual rate of $357,500,000,000, up $1,500,000,000 over August; for the 9-month period ended September 30, 1958;

personal income ran at $351,500,000,000 yearly, an increase of $4,000,000,000 over the same period in 1957.

October 17

△ Loadings of rail freight rose to 686,138 cars which shows an increase for the fifth successive week.

△ Hanna Coal & Ore Corp. announced filing of 313,038 additional shares of common stock with the SEC for subscription, pro rata, by it shareholders.

October 20

△ The Labor Dept. reported that workers drawing jobless pay in the week ended October 4 totaled 1,765,200 down 48,500; in the week ended October 11, initial claims increased 4000 to 281,900.

△ The AISI reports that the operating rate of the steel industry for the week of October 20 is scheduled at 2,018,000 tons (74.8 per cent of capacity). This compares with 2,003,000 tons one week ago (74.2 per cent capacity) and 2,052,000 tons one year ago. Index of production for the week is 125.6

△ The Aluminum Assn. reported primary aluminum production in the United States during September, 1958 was 124,713 short tons compared with 125,416 short tons in August, 1958 and 129,277 tons in September, 1957.

△ The Industrial Heating Equipment Assn. reported that new orders for industrial furnaces in September, 1958 were $4,846,000 compared with $3,533,000 in August, 1958; for the three quarters ended September 30, 1958 new business totaled $31,351,000 compared with $59,066,000 in the same period of 1957. New orders for induction heating equipment in September totaled $888,000; new business to September 30, 1958 amounted to $4,679,000 compared with $7,328,000 in 1957.

October 21

△ Custom smelters increased their price of copper 1½¢ to 30¢ per lb, which is 2½¢ above level charged for copper by major U. S. producers.

October 23

△ Anaconda and Kennecott boosted charges for copper by 1½¢ to 29¢ per lb.

△ The ARCI reports that deliveries of new domestic freight cars in September, 1958 totaled 2131 compared with 2151 in August, 1958 and 8450 in September, 1957. Orders in September totaled 1582 compared with 1773 in August, 1958 and 3162 in September, 1957. Backlog of cars on order as of October 1, 1958 stood at 24,982 compared with 25,611 on September 1, 1958 and 71,981 on October 1, 1957.

October 24

△ Federal Reserve Banks in Philadelphia, Richmond, St. Louis, Minneapolis and Dallas raised their discount rates from 2 to 2½ per cent.

△ The AISC reports that bookings of fabricated steel in September, 1958 totaled 255,584 tons compared with 225,768 tons in August, 1958; shipments in September, 1958 totaled 313,701 tons compared with 298,012 tons in August, 1958; bookings for the first nine months are 2,075,283 tons compared with 2,533,177 tons in the same period of 1957; shipments for this period of 1958 totaled 2,819,479, 10 per cent less than the same period of 1957. Backlog of future work as of September 30 totals 2,046,799 tons.

△ Algoma Steel Co. increased price on structural steel $4 to a new price of $110 a ton.

October 27

△ The AISI reports that the operating rate of the steel industry for the week of October 27 is scheduled at 2,009,000 tons (74.4 per cent of capacity). This compared with 2,026,000 tons one week ago (75.1 per cent capacity) and 2,041,000 tons one year ago. Index of production for the week is 125.1.

△ Production of U. S. copper mines has increased an estimated 24,000 tons monthly to meet increased demand and help offset shortages created by strikes in Rhodesia, Canada and the U. S.

October 29

△ The Aluminum Assn. reported that shipments of aluminum sheet and plate in September, 1958 totaled 100,513,000 lb, compared with 91,924,000 in August, 1958. Shipments of aluminum foil for September, 1958 totaled 17,338,078 lb compared with 16,583,432 lb in August, 1958.

△ F. W. Dodge Corp. reports that construction contracts in U. S. during September, 1958 totaled $3,215,919,000, 26 per cent over September, 1957. The cumulative total of contracts for the first nine months of 1958 totaled $26,985,813,000, 7 per cent over the same period of 1957.

△ Mallory-Sharon Metals Corp. reduced the base price of titanium billet stock from $4.10 to $3.80 per lb. Sponge has been cut to $1.62 per lb.

△ Shipments of iron and steel castings for August, 1958 totaled 932,611 short tons compared with 902,227 tons in July, 1958 and 1,287,870 tons in August, 1957.

October 30

△ The Commerce Dept. reported that incoming business in September reached $26,800,000,000, an increase of $700,000,000 over August, 1958 and up $300,000,000 over September, 1957.

△ The Commerce Dept. reported that U. S. exports in September totaled $1,231,000,000, a drop of $206,000,000 from September, 1957.

△ Westinghouse Electric Corp. reported, for the quarter ended September 30, 1958, sales amounting to $460,538,000, net income $19,038,000 equal to $1.09 per share. For the same period in 1957, sales were $494,334,000, net income $18,487,000 or $1.07 per share. For the nine-month period ended September 30, sales totaled $1,384,499,000, net income $49,011,000 or $2.79 a share; for the same period in 1957 sales totaled $1,477,273,000, income $49,102,000 or $2.83 per share.

△ Allis-Chalmers Manufacturing Co. reported sales of $124,000,000, earnings of $4,929,106 or 60¢ a share for the quarter ended September 30, 1958 compared with earnings of $3,421,866 or 42¢ a share in the same period of 1957. For the first nine months, 1958 sales totaled $393,748,854, earnings $13,328,894 or $1.62 a share; 1957 sales were $419,354,514, earnings $14,470,249 or $1.75 a share.

△ Eastern Stainless Steel is offering common stockholders rights to subscribe for $5,123,600, 5 per cent convertible, 15-year debentures at the rate of $100 principal amount of the debentures for each 14 shares held on record at October 28. Proceeds are to be used to retire $4,000,000,000 of 4½ per cent notes, and the balance added to a new $4,000,000 bank credit for expansion and working capital.

October 31

△ The AISI reported that the iron and steel industry's payroll for 94.9 per cent of the industry for hourly and salaried employees totaled $294,277,422 during Sep-

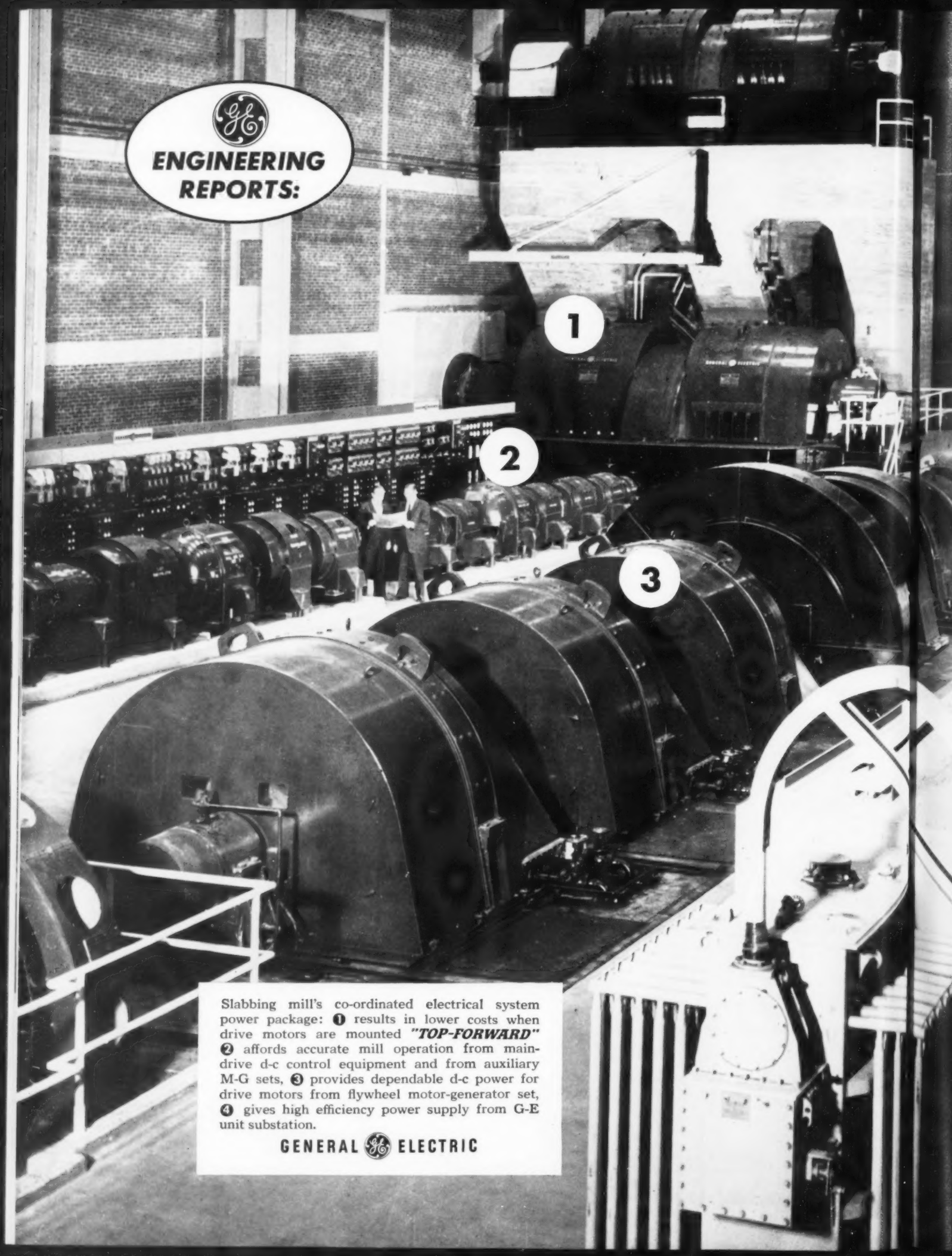
tember, 1958, against $283,058,572 during August, 1958. Average hourly payroll cost for wage earners was $3.274, compared with $3.265 in August, 1958 and $3.022 in September, 1957. Fringe benefits amounting to 33¢ per hr are not included. Total employment during September, 1958 totaled 527,407, compared with 514,895 in August, 1958; average hours worked per week in September was 36.5 compared to 34.9 in August.

△ Climax Molybdenum Co. announced that effective November 1 prices of its molybdenum products would be increased approximately 5 per cent, setting for molybdenite concentrate $1.25, canned molybdic oxide $1.47, ferromolybdenum $1.76.

STEEL COMPANIES QUARTERLY FINANCIAL REPORTS—JULY 1, 1958 TO SEPTEMBER 30, 1958

	Period	1958 Net sales	1958 Net profit	1958 Earnings per share	1957 Net sales	1957 Net profit	1957 Earnings per share
Acme Steel Co.	3rd quar.	$ 32,998,423	$ 1,631,088	$ 0.59	$ 33,692,937	$ 1,447,145	$0.52
	9 mo.	90,898,541	3,208,284	1.16	116,322,018	5,388,918	2.18
Allan Wood Steel Co.	3rd quar.	12,555,240	538,650	0.69	14,325,642	(142,086)*	....
	9 mo.	37,765,061	877,615	1.00	50,691,694	1,293,494	1.60
Allegheny Ludlum Steel Corp.	3rd quar.	45,115,055	1,155,429	0.30	60,234,127	1,983,861	0.51
	9 mo.	144,350,345	2,527,396	0.66	213,944,192	9,725,952	2.52
Armco Steel Corp.	3rd quar.	214,390,243	12,876,598	0.87	270,631,446	17,600,617	1.22
	9 mo.	629,879,986	33,833,342	2.29	834,852,263	56,183,723	3.88
Atlas Steels, Ltd.	3rd quar.	.....	381,000	0.35	.....	168,400	0.16
	9 mo.	.....	1,289,000	1.19	.....	1,747,000	1.62
Barium Steel Corp.	3rd quar.	6,793,471	(206,903)	....	16,275,000	123,000	0.12
	9 mo.	21,943,826	(1,267,334)	....	.....	.....	.....
Bethlehem Steel Co.	3rd quar.	472,391,333	26,240,677	0.55	638,698,351	40,051,465	0.86
	9 mo.	1,476,000,044	80,063,586	1.68	2,002,033,152	143,752,627	3.10
Carpenter Steel Co.	1st quar.	11,992,698	66,120	0.07	12,763,701**	948,059**	1.10**
Colorado Fuel & Iron Corp.	3rd quar.	.....	1,607,143	0.43	.....	3,295,509	0.93
	9 mo.	.....	1,280,435	0.26	.....	12,200,223	3.48
Continental Steel Corp.	3rd quar.	12,304,306	1,021,236	1.98	9,372,609	530,475	1.03
	9 mo.	35,732,931	2,690,990	5.21	33,788,839	2,216,785	4.29
Copperweld Steel Co.	3rd quar.	22,931,222	898,028	0.80	24,737,022	157,045	0.11
	9 mo.	63,365,189	690,890	0.54	92,723,587	2,147,025	1.87
Crucible Steel Co. of America	3rd quar.	43,355,875	854,374	0.22	49,524,698	(225,119)	....
	9 mo.	129,221,644	1,253,701	0.33	185,829,043	5,820,877	1.60
Detroit Steel Corp.	3rd quar.	15,382,220	306,533	0.08	16,564,162	159,889	0.03
	9 mo.	42,280,500	4,694	(0.06)	65,333,846	2,023,853	0.60
Eastern Stainless Steel Corp.	3rd quar.	13,245,074	753,449	1.05	9,649,271	298,693	0.42
	9 mo.	34,824,769	1,686,676	2.35	37,277,536	1,900,783	2.65
Firth Sterling, Inc.	3rd quar.	3,279,900	(218,100)	(0.16)	5,446,200	19,500	0.01
	9 mo.	10,204,000	(771,200)	(0.56)	22,782,900	831,900	0.57
Granite City Steel Corp.	3rd quar.	31,292,514	2,320,977	1.08	27,981,573	1,623,303	0.75
	9 mo.	88,738,226	6,217,560	2.89	93,969,833	7,873,259	3.67
Inland Steel Co.	3rd quar.	167,535,650	12,118,009	2.11	184,505,748	13,382,172	2.36
	9 mo.	477,717,219	32,197,740	5.59	591,286,590	43,146,628	7.60
Interlake Iron Corp.	3rd quar.	20,967,931	339,271	0.15	25,741,517	1,431,629	0.64
	9 mo.	58,510,458	1,584,461	0.71	83,879,513	5,066,277	2.26
Jessop Steel Co.	3rd quar.	.....	.....	....	.....	.....	....
	9 mo.	.....	.....	....	.....	.....	....
Jones & Laughlin Steel Corp.	3rd quar.	161,828,000	6,698,000	0.81	218,470,000	11,377,000	1.46
	9 mo.	462,627,000	12,389,000	1.45	650,828,000	37,970,000	4.88
Kaiser Steel Corp.	3rd quar.	41,182,441	(1,922,742)	(0.85)	.....	.....	....
	9 mo.	134,495,495	2,047,395	(0.02)	164,090,163	18,353,642	5.13
Keystone Steel & Wire Co.	3rd quar.	.....	1,523,270	0.81	.....	1,145,255	0.61
Lone Star Steel Co.	9 mo.	34,965,708	645,345	0.20	76,026,479	9,439,862	3.25
Lukens Steel Co. (Ending September 6)	12 weeks	21,724,553	479,982	0.51	29,806,916	2,330,637	2.44
	36 weeks	73,073,731	3,537,391	3.71	91,494,385	8,309,901	8.71
McLouth Steel Corp.	3rd quar.	47,900,000	2,766,781	1.60	45,900,000	2,166,371	1.20
	9 mo.	112,400,000	5,083,618	2.60	136,800,000	7,535,966	4.38
National Steel Corp.	3rd quar.	150,063,398	10,892,433	1.47	149,717,037	8,041,074	1.08
	9 mo.	381,351,592	21,221,621	2.86	493,065,495	34,149,921	4.60
Pittsburgh Steel Co.	3rd quar.	30,576,338	(291,638)	(0.39)	44,319,757	654,049	0.21
	9 mo.	93,603,501	(1,824,297)	(1.77)	141,596,176	4,275,372	2.08
Republic Steel Corp.	3rd quar.	222,146,170	15,184,641	0.97	277,176,474	20,121,297	1.29
	9 mo.	644,423,661	39,089,243	2.50	972,388,549	73,039,194	4.68
Sharon Steel Corp.	3rd quar.	24,314,361	66,484	0.06	31,680,070	213,852	0.19
	9 mo.	69,036,675	(952,450)	(0.87)	117,175,076	2,943,877	2.67
United States Steel Corp.	3rd quar.	872,187,927	74,922,924	1.27	1,042,782,049	97,555,683	1.70
	9 mo.	2,535,329,741	210,573,654	3.56	3,379,580,712	328,976,991	5.77
Universal-Cyclops Steel Corp.	3rd quar.	22,069,473	1,087,108	0.66	20,866,085	676,505	0.42
	9 mo.	57,945,537	1,910,079	1.17	73,584,793	3,111,054	1.91
Washington Steel Corp.	Quarter	.....	553,963	0.90	.....	321,550	0.52
	Year	.....	800,631	1.26	.....	1,786,397	2.89
Woodward Iron Co.	3rd quar.	.....	974,929	0.46	.....	1,266,535	0.60
	9 mo.	.....	2,714,831	1.28	.....	2,367,230	1.12
Wheeling Steel Corp.	3rd quar.	56,003,000	1,842,000	0.72	57,802,000	1,714,000	0.66
	9 mo.	159,680,000	4,811,000	1.80	198,083,000	9,107,000	4.02
Youngstown Sheet and Tube Co.	3rd quar.	120,027,555	3,641,906	1.06	170,304,765	9,890,147	2.88
	9 mo.	359,550,052	11,454,647	3.32	541,671,893	31,814,556	9.25

* Numbers in parentheses indicate losses.
** Does not include Carpenter of New England.



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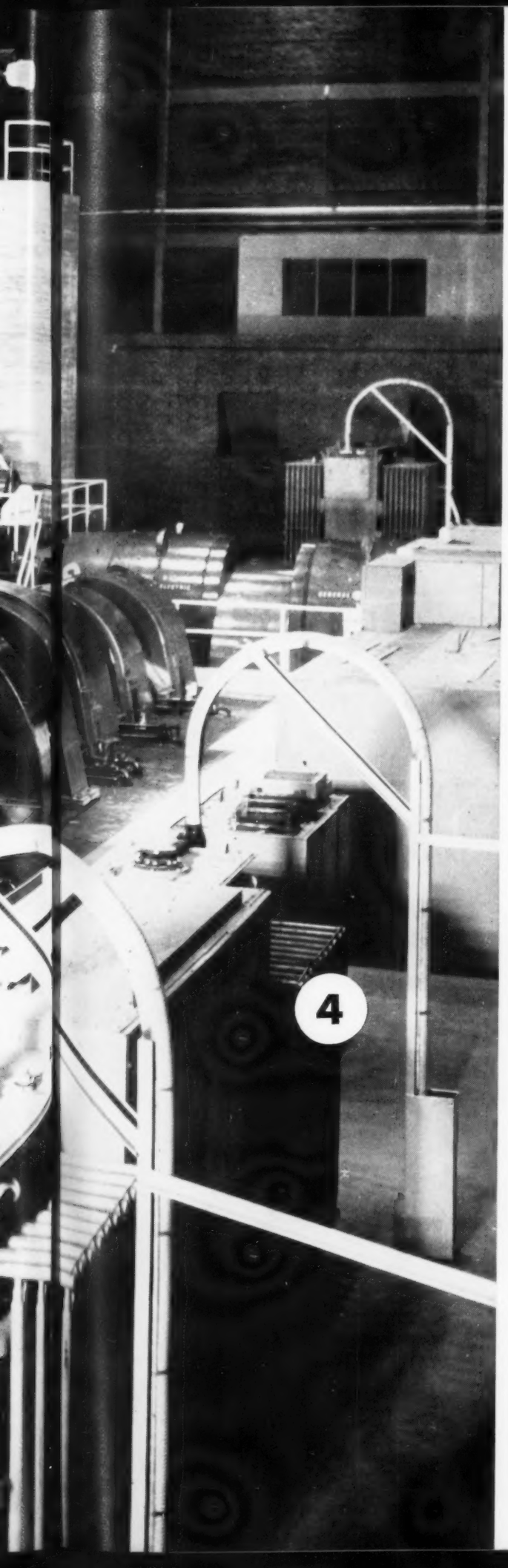
GENERAL ELECTRIC



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GENERAL ELECTRIC

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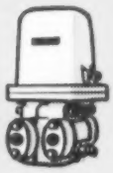

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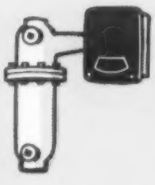
...magnetic amplifiers...no vibrators
...no mechanical rebalancing



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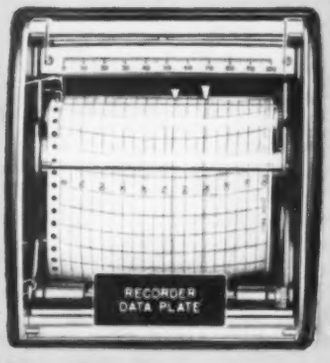

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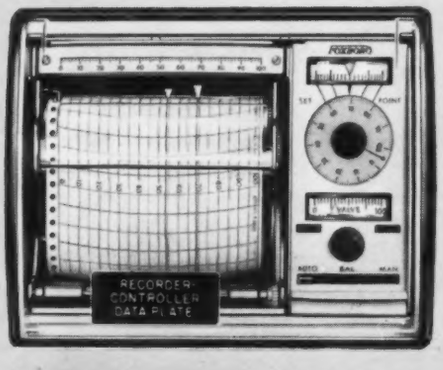
Electronic Consotrol Recorders (shown ¼ actual size) use a simple, powerful pen motor which can be operated directly from transmitter signal without amplification. Available in 1 and 2 pen models.



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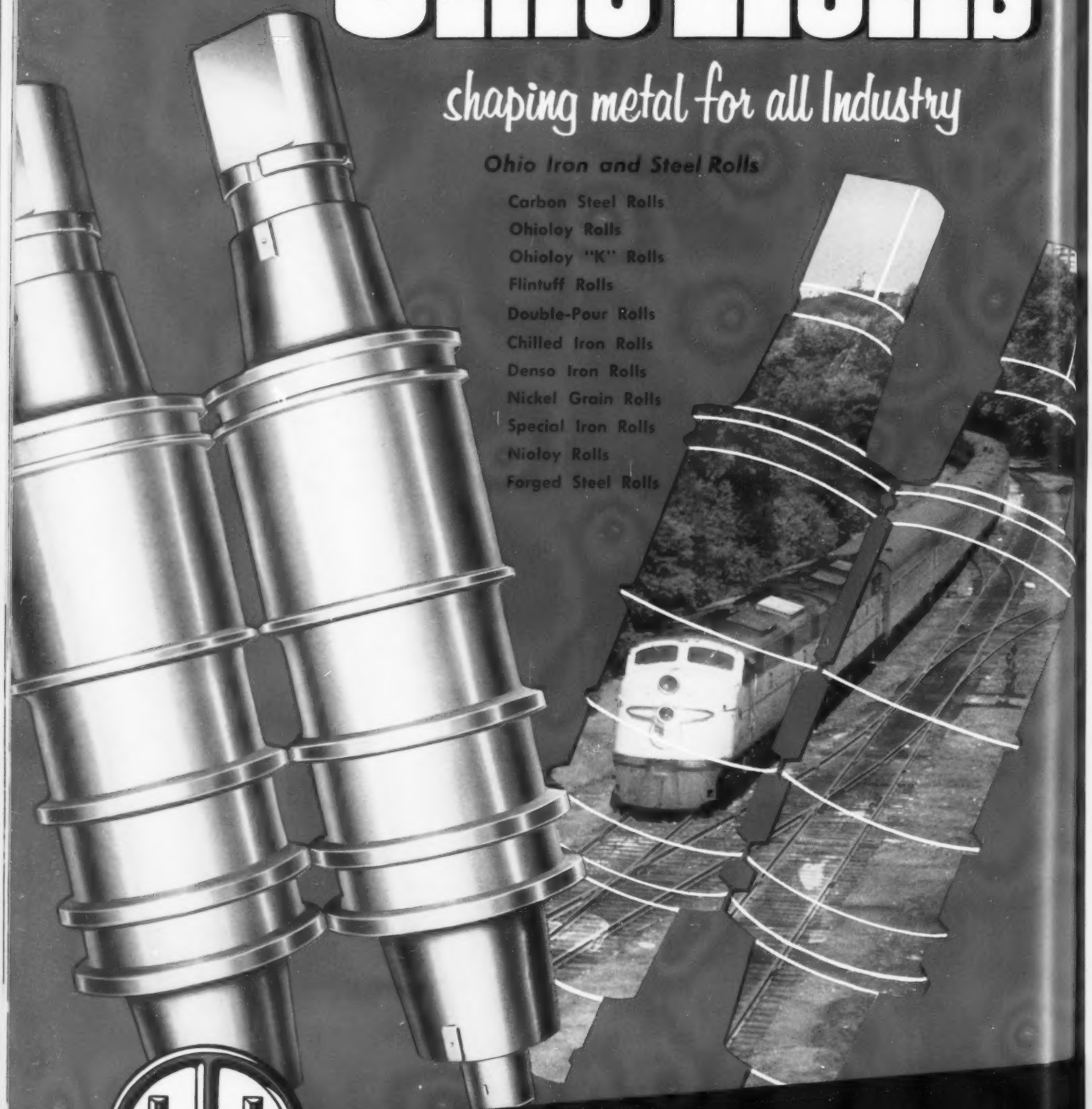
- Nioloy Rolls
- Forged Steel Rolls



THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO

Plants at Lima and Springfield, Ohio

LIMA... *Virtually at the center of the steel industry*

OR22

Industry News...

NEW PLATE MILL NOW OPERATING AT FONTANA

△ A new plate mill for rolling wider plate than has ever been produced in the far West was put into operation October 15 at Kaiser Steel Corp.'s Fontana, Calif., plant.

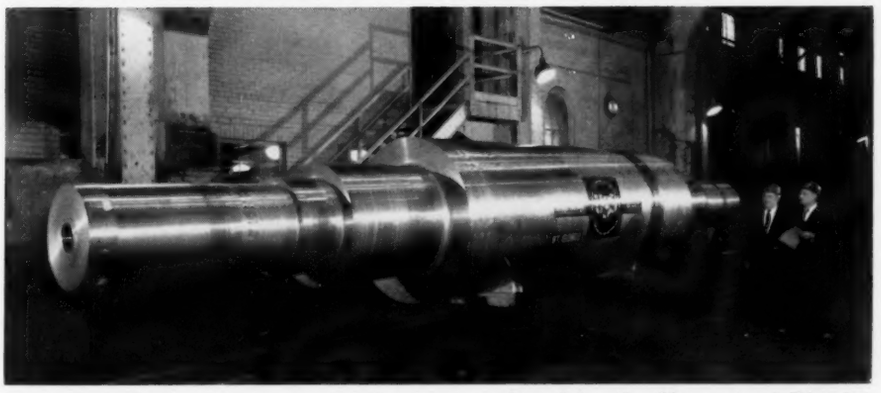
The new mill will roll steel plate up to 126 in. wide and 720 in. long. It replaces the Fontana plant's former plate mill which produced maximum widths of 96 in. by 600 in. long. The new facilities will not only produce wider plate, but they will substantially increase Kaiser Steel's plate rolling capacity. The mill will also make possible the production of line pipe in the largest sizes now being used by the pipeline transmission industry.

Most of the new equipment was installed while the old mill continued daily production a few feet away. Final completion, however, made it necessary to shut down plate production for four weeks.

Included in the new facilities are a four-high, 148-in. reversing mill, a huge hydraulic end shear to cut plate to length, and two levelers to flatten the plate.

The new mill is the third major unit to be completed in Kaiser Steel's current $214,000,000 expansion program. A new 86-in. hot strip mill and facilities to double electrolytic tin plate capacity began break-in operations this summer. Scheduled for operation later this year are three new basic oxygen steelmaking furnaces, a new universal slabbing mill, 90 additional coke ovens and a fourth blast furnace. The expansion will virtually double steel ingot capacity at Fontana. Kaiser Engineers is prime contractor for the entire program.

GENERATOR ROTOR FORGED AT HOMESTEAD



Typical of the large commercial forgings produced by the Homestead District Works of the United States Steel Corp. is this generator rotor weighing 193,800 lb and measuring 34 ft 10 in. long. Production facilities for such forgings are now being expanded at Homestead with the addition of seven vertical heat-treating furnaces and three large turning and boring lathes. Other improvements are being made in the Forge Division at Homestead as part of the corporation's Pittsburgh district modernization and expansion program.

ROLL FIRST STEEL ON INDIAN MILL

First steel rolled on the new 46-in. blooming mill signals near completion of the Tata Iron & Steel Co.'s two-million ton expansion program. Designed and constructed by Kaiser Engineers, the completed $140,000,000 program will increase Tata's steel output by better than half. Previously placed in operation: two open hearth furnaces and two batteries of coke ovens. Pending completion are the billet mill and structural mill.

TO ADD MERCHANT MILL AT WISCONSIN STEEL

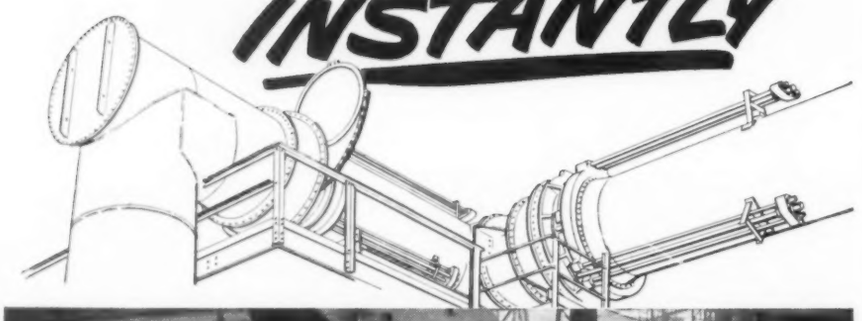
△ Plans for construction of a new merchant mill at Wisconsin Steel Works of International Harvester Co. were announced by Roy A. Lindgren general manager of the company's steel division. The new mill will cost more than $12,000,000.

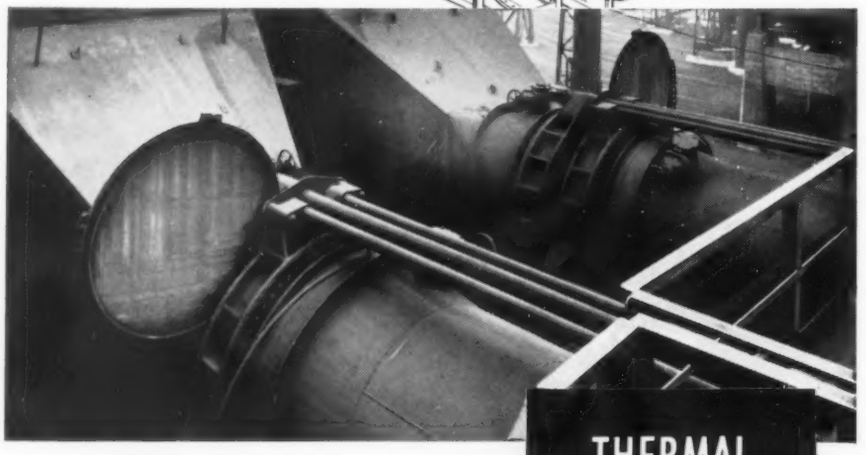
The mill will be situated on a 17-acre plot of ground, part of the present plant property of Wisconsin Steel in South Chicago.

The new mill will roll small rounds squares, flats, channels and angles—replacing two older and smaller mills in this function.

The new mill will require approximately two and a half years to construct and several months will

HOW TO CLOSE LARGE GAS MAINS INSTANTLY





Bailey ENGINEERS

THERMAL EXPANSION GOGGLE VALVES

Bailey Mechanical Goggle Valves are produced in diameters from 6" to 72".

A powerful, completely dependable force of nature—the linear expansion and contraction of steel—is used to open and close gas mains equipped with these valves. When steam is applied to three sets of tubes they expand to separate the flanges, thereby freeing goggle plate for swinging to open or closed position.

Designed to protect men and equipment, Bailey Goggle Valves are safe and efficient on gas washers, blast furnace mains, precipitators and boiler plants. Diameters range from 36" to 120".

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA

be needed for completion of engineering work before contracts for construction can be let.

The mill, to be known as No. 6 Mill, will roll small rounds, squares flats, channels, and angles which are now made on two smaller old mills. Its capacity will be approximately 20,000 tons a month, which will give Wisconsin Steel total merchant mill capacity of about 62,000 tons a month, an increase of 10 per cent.

Under typical operation, International Harvester normally uses about half of the annual production of its steel division and sells the other half. During the past year it sold some $59,000,000 of steel, pig iron and coke by-products to other companies.

The Wisconsin Steel plant now includes 11 open hearths, three blast furnaces and five rolling mills. The last figure includes the two smaller units which the new mill eventually will replace.

UNLOADER OPERATING ON INTERLAKE FURNACE

△ Ore stockpiling at a Chicago blast furnace plant has been substantially increased by the completion of a new man trolley unloader.

Built by Dravo Corp., under contract from Arthur G. McKee & Co., the unloader has just gone into service at the Federal Furnace plant of Interlake Iron Corp.

The unloader, which can empty ore boats at a peak rate of more than 1850 net tons an hour, represents just one phase of a major dock and ore yard expansion program still under way at the plant.

Ore unloaded at Interlake's dock on the Calumet River will be transferred by a new belt conveyor to a receiving trough at a new ore yard. There a Dravo ore bridge now being erected will stockpile it for subsequent loading on transfer cars bound for the blast furnaces.

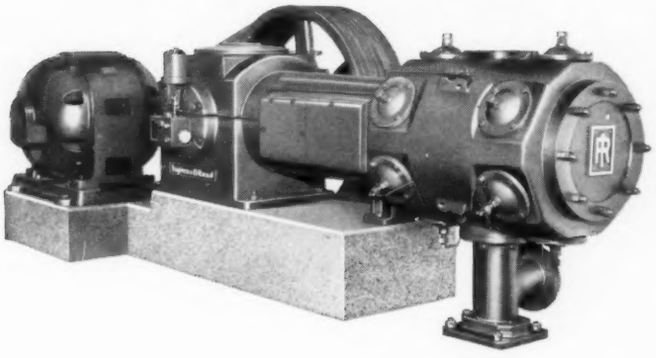
The unloader has a 300-cu-ft bucket of approximately 20-net-ton capacity. A ring-type turntable on the man trolley permits 90-degree rotation of the bucket in either direction for more efficient removal and cleanup of ore from the holds of boats.

Ore is fed onto the belt conveyor through a 95-ton hopper. One complete digging cycle, with the

NEW COMPRESSORS

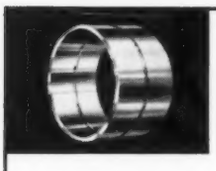
...with heavy-duty features proven in larger Ingersoll-Rand compressors

ESH* (horizontal)



ESV* (vertical)

*The same compressor in either horizontal or vertical arrangement – 20 to 150 hp sizes, single-and multi-stage, pressures up to 5000 psi and vacuums.



Full-floating aluminum bearings never need adjustment

The full-floating bearings "roll with the punch," taking each thrust on a different portion of the shell. They are foolproof, and never require fitting or adjustment. Main and crankpin bearings are made of I-R's special aluminum bearing alloy, which has higher load capacity and better heat conductivity than other bearing materials.

Air-cushioned Channel Valves give unmatched performance

Known the world over for lasting efficiency, dependability and quiet operation, Ingersoll-Rand air-cushioned Type A Channel Valves are entirely different in design and principle from any other valves in use. Type A Channel Valves were developed especially for modern compressor speeds, and feature a separate stainless-steel seat plate which can be reversed or replaced for new life.

Never a need for adjustments– frame is kept sealed!

Here's an entirely new line of compressors, built to run longer — much longer. They're more compact, more efficient, and require less attendance, less maintenance. They offer greater capacity in less space, and are ruggedly built and highly refined to take years of continuous hard service.

All running parts are precision-machined and need no fitting or adjusting, so the frame is sealed — dirt stays out, and the major causes of wear are eliminated!

There are many design features—including filtered force-feed lubrication and full-floating self-adjusting metallic packing — that have heretofore been found only in larger Ingersoll-Rand compressors. Let your I-R representative tell you more about these new compressors, and how they can save you money.

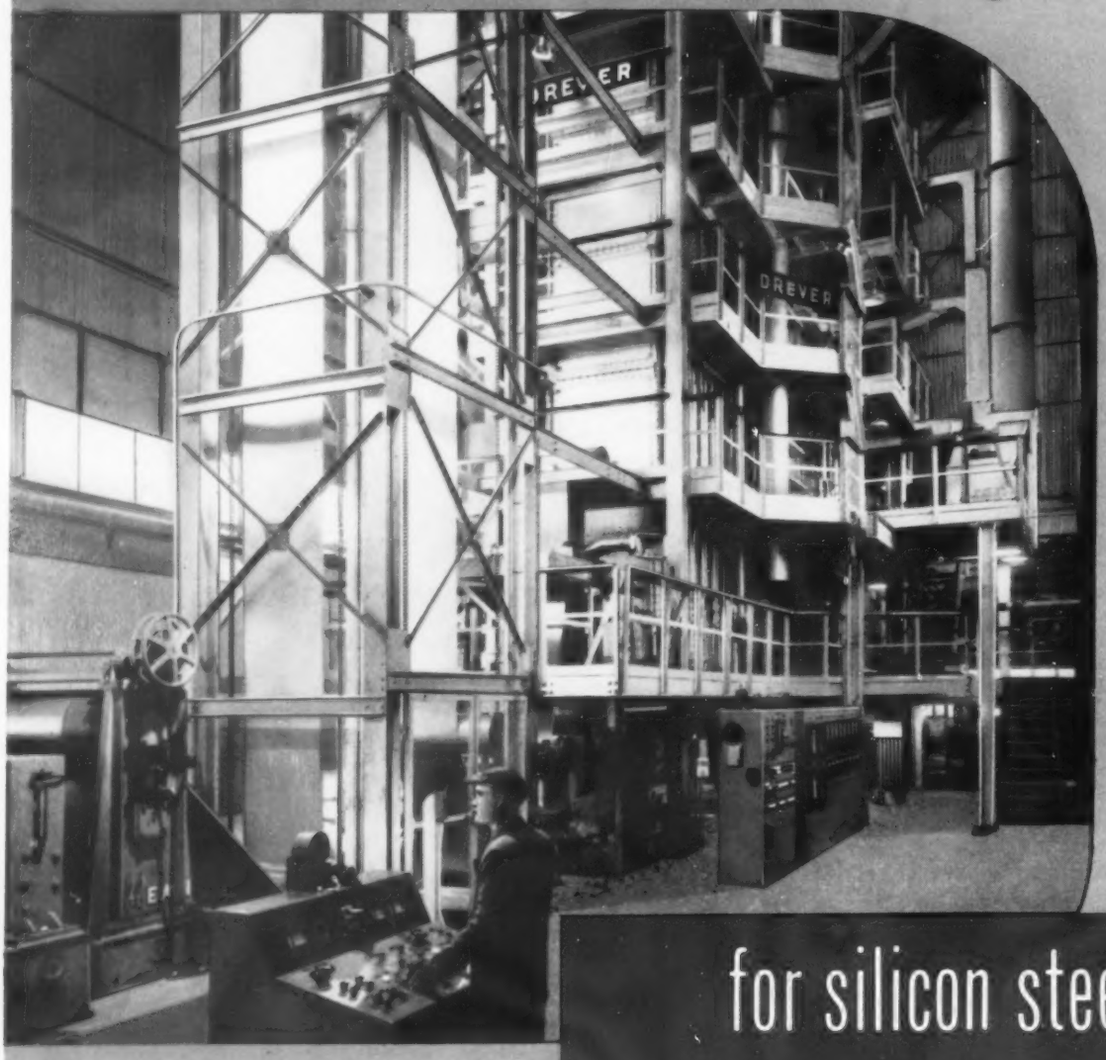
Ingersoll-Rand

I-815 **11 Broadway, New York 4, N. Y.**

In engineered products, there's no substitute for experience!

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

DREVER
Continuous Strip Annealing Furnace Line



for silicon steel

Delivery end of Drever gas-fired radiant tube heated vertical annealing furnace for silicon steel strip installed at Empire Steel Corporation, Mansfield, Ohio.

This furnace was designed and installed by the Drever Company to produce 8 tons per hour of silicon steel strip. The heating and soaking zones are gas-fired radiant tube heated; the tubes having a connected load of 13,500 CFH of natural gas.

The furnace has been engineered to handle silicon steel strip in thicknesses from 0.017" to 0.025", in widths from 24" to 42", and for speeds from 60 to 180 FPM.

Drever continuous annealing lines for Tin Plate, Galvanized Stock, other Low Carbon Steel and Non-Ferrous Strip in capacities up to 30 tons per hour, provide an economical investment in tonnage production of quality material.

DREVER COMPANY

Red Lion Rd. & Philmont Ave.

BETHAYRE S, PA.

38

bucket traveling from boat to hopper and back again, requires only 39 sec.

The trolley travels at a rate of 960 fpm while the unloader tower moves at 115 fpm. The tower, which is more than 100 ft tall and weighs approximately 880 tons, operates along 648 ft of track on two rails 60 ft apart. Installation of the unloader required alteration of the dock to support the tracks.

Boom of the unloader is retractible. When extended, it projects 98 ft beyond the water side leg. It also extends 78 ft beyond the land side leg. This means that the bucket can be operated almost 62 ft from the dock face.

The unloader is driven by a total of 16 adjustable voltage d-c motors with a combined rating of 2077 hp, operating on a 4160-volt, three-phase, 60-cycle a-c power supply.

The new ore bridge will have a 390-ft span between legs. Its bucket capacity will be the same as that of the unloader but it will have a free-digging rate of 1560 net tons an hour, and the man trolley will rack back and forth at 1080 ft a minute.

KENNECOTT AGREES TO BUY OKONITE ASSETS

△ Kennecott Copper Corp. and the Okonite Co. have announced plans to affiliate.

Charles R. Cox, president of Kennecott, and R. Stuart Keefer, president of Okonite, announced that a contract has been signed by which Kennecott would acquire through a new subsidiary company the properties, assets, business and good will of Okonite in exchange for shares of Kennecott common stock on a share-for-share basis.

The proposal is to be submitted to Okonite stockholders at a special meeting November 24 and if approved would take effect immediately.

Founded 80 years ago, Okonite is best known for its premium-grade insulated wires and cables furnished for power transmission and distribution, control and signal systems and electronic and communication circuits.

Okonite operates manufacturing plants in Passaic, Paterson and North Brunswick, N. J., and maintains a nationwide warehousing, sales and distribution network.

"The merger is advantageous for Kennecott," Mr. Cox said, "because it will improve our position in the wire and cable business. At the same time it will result in wider and stronger competition among the industry's leaders.

While the present Okonite company will be dissolved, a new company with the same name will be formed and operate as a subsidiary of Kennecott.

From Okonite's standpoint, Mr. Keefer stated: "The new affiliation will provide the resources and backing that will enable Okonite to take better advantage of increasing opportunities for marketing wire and cable in both old and new areas in the electrical industry."

TIMKEN COMPLETES NEW VACUUM ARC FURNACE

△ The Steel and Tube Division of the Timken Roller Bearing Co. recently announced the completion of its first consumable electrode vacuum arc furnace. John E. Fick, vice president of the Division, said

How to cut mill downtime due to bearing failures...

use A·B·K* bearings

Roll neck and slipper bearings made of A-B-K material often outwear metal bearings many times. Their ability to cushion impact loads without peening, scoring or heat-checking protects roller necks, housings and chucks. Simplicity of design and light weight speed installation. Can be lubricated with grease, oil or water *alone*. Ask our engineers to help you solve your specific problems.

- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

A·B·K
LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

AMERICAN Brake Shoe COMPANY
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HERC-ALLOY

THE ORIGINAL ALLOY STEEL CHAIN

● Herc-Alloy is a special all-purpose chain with long-wearing properties and high resistance to impact loading.

● Herc-Alloy is sold in running lengths and in all types and sizes of sling chains assembled to customers' specifications.

● CM also produces a complete line of chain attachments and welded chain of all types including stainless steel and bronze.

● Write for literature covering Herc-Alloy Sling Chains, including helpful information on their assembly, care, use and inspection.

Hammerlok®

COUPLING LINKS

● Assemble or rebuild your own Herc-Alloy sling chains with all components furnished by your local distributor. Hammerlok is simple, safe, reusable. New Herc-Alloy assemblies can now be ordered with welded or Hammerlok Coupling Links as desired.

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Herc-Alloy®

that the new vacuum furnace, completed at a cost of $500,000, will produce a cleaner, sounder steel with very high fatigue strength and ductility. Capacity of the furnace is approximately 200 tons of alloy steel per month. Steel produced by the new method will be used for high stress bearing applications making possible longer bearing life. The steel will also be suitable for vital aircraft, rocket and missile parts.

The quality of the steel, as related to cleanliness, is obtained because impurities are prevented from entering during the melting process, because impurities in the metal are sucked out by the vacuum as a gaseous phase when the metal is molten and through levitation. Other virtues of vacuum melted steel are improved impact strength, increased stress rupture strength at elevated temperatures and lengthened fatigue life.

A consumable electrode vacuum arc furnace was selected over the other vacuum methods available due to three basic reasons.

1. This melting process ends problems of contamination from three basic sources—crucible, air and slag.

2. The furnace can produce larger ingot sizes than other vacuum melting furnaces.

3. Directional solidification gives uniform mechanical properties throughout the ingot, particularly in the transverse direction, preventing any zones of weakness.

NEW ELECTRIC FURNACE OPERATING AT LUKENS

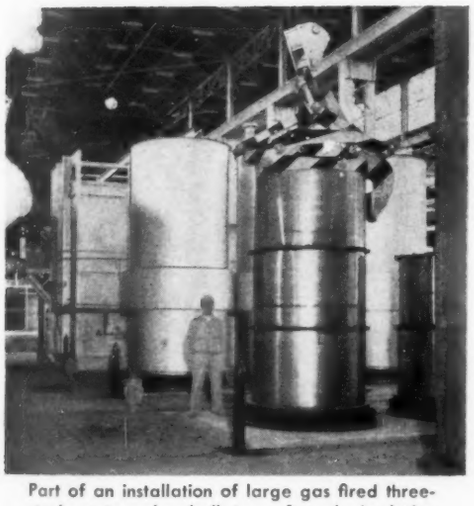
△ The second of three major phases of Lukens Steel Co.'s current $33,000,000 expansion program neared completion as the company began charging and pouring heats in its new electric steelmaking furnace.

Once in commercial production and integrated with other facilities, the new furnace will increase Lukens' rated ingot capacity by 24 per cent, from 750,000 to 930,000 tons annually. The furnace melts 100 tons of steel in each heating cycle.

The first major phase of the expansion program, nine massive soaking pits, was completed last July. The remaining major phase, a new 140-in. rolling mill and added soaking pits, is scheduled for completion early in the spring of 1959.

Two large EF combination gas fired and electrically heated furnaces for uniformly annealing, normalizing, and galvanizing strip — continuously.

designed engineered and *Specially Built*



Part of an installation of large gas fired three-stack rectangular bell type forced circulation special atmosphere furnaces for annealing strip.

for continuous and batch processing of ferrous and non-ferrous strip

We are in position to design, build and put into operation: continuous or batch type equipment for hot or cold rolled, high or low carbon steel, stainless, silicon, tinplate, aluminum, brass, bronze or any other ferrous or non-ferrous metal—for bright annealing, normalizing, galvanizing, aluminizing, tinning or any other process—in the size and type best suited to your plant, process, product or production requirements. No job is too large or too unusual.

Put your production furnace problems up to experienced engineers—it pays.

EF **THE ELECTRIC FURNACE CO.**

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION *Salem - Ohio*

Canadian Associates • CANEFCO LIMITED • Toronto 13, Canada

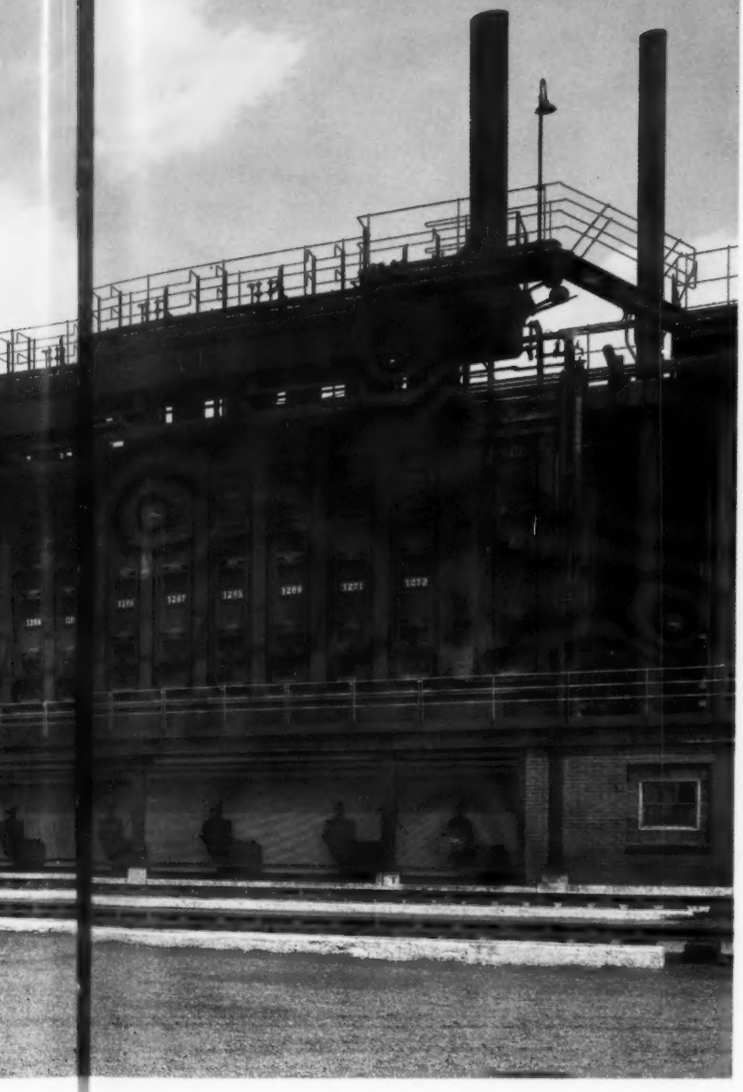
This large EF combination electric and gas fired installation flame cleans, uniformly anneals and galvanizes strip continuously.

Eastern steel plant now has

COAL HANDLING SYSTEM FOR THE COKE PLANT—Coal is conveyed to the breaker and balance building (center foreground), to the mixer and hammermill building, to the junction house (between stacks), and finally to the coal bin over the ovens.

65 NEW OVENS—These new ovens were furnished by Koppers, and were put into operation in June, 1957.

12 coke oven batteries, 758 ovens . . . ALL designed and built by Koppers



A giant Eastern Steel Plant recently put into operation a new battery of 65 Koppers-Becker Underjet Coke Ovens. This coke oven battery is the twelfth at this plant—*all designed and built by Koppers.* This battery is designed for underfiring with either blast furnace or coke oven gas. It has a daily coal carbonizing capacity of 1,450 net tons, and gives the plant a total carbonizing capacity in excess of 15,000 tons per day. To help supply the expanded coke plant, a new coal handling system was designed and installed by Koppers.

At this same plant, Koppers contributed further to the expansion of facilities by designing and supervising construction of a new open-hearth shop, and the installation of soaking pits and a 45″ by 90″ Universal slabbing mill.

Repeat Orders Signify Satisfied Customers. Since 1907 Koppers engineers have been working with coke ovens: reducing operating costs . . . increasing yield of chemicals . . . improving heating control. Koppers has built the majority of coke ovens in the United States. Most of this business, like the 12 batteries built for this Eastern Plant, has been repeat business—the kind you get only if your product has given satisfactory service.

Koppers coke plant layouts are engineered to fit individual requirements and to solve all coke plant problems dealing with coal preparation and handling, coal-chemical recovery, light oil purification and refining, phenol recovery, and associated processes. Koppers also welcomes repair and replacement work for coke ovens and auxiliaries.

If you want help or advice with any steel-plant expansion program, call on Koppers.

SEVEN 385-TON OPEN-HEARTH FURNACES were designed by Koppers for this giant plant.

KOPPERS®

50 YEARS OF ENGINEERING AND CONSTRUCTION SERVICE 1908···1958

KOPPERS

No. 6

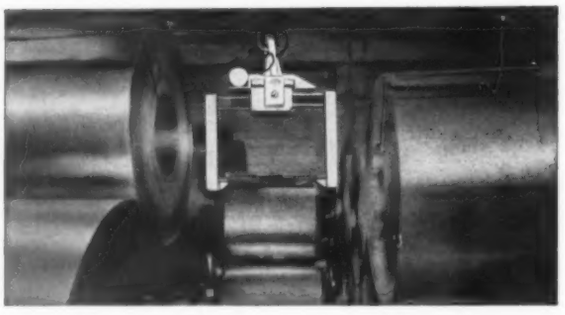
Facts About: MANSAVER® GRABS

TELESCOPING

Construction Permits

EXTRA CLOSE PILING

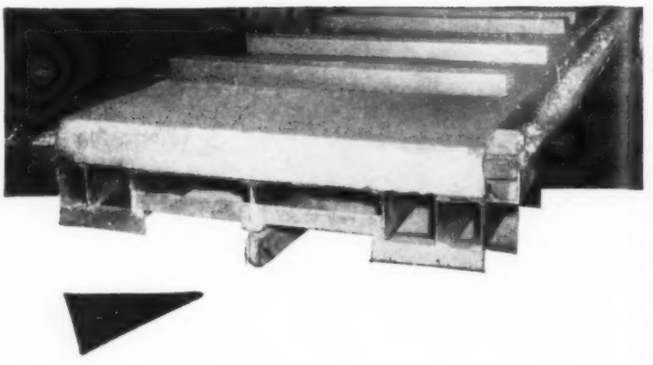
As shown below, this Mansaver style 1418 Coil Grab can stack coils evenly, close together and higher because of its telescoping construction. Higher and closer stacking is the equivalent of increased floor space. Floor space so saved means more space for manufacturing. The 1418 Coil Grab may also be purchased with a motor-driven turntable for rotating coil for proper unwinding.



Mansaver Grabs are available in manual, semi- and fully-automatic, and motor-operated models for lifting sheet, coils, rods, and other steel mill products. New grabs are being developed constantly. Write for names and addresses of neighboring plants where you can see Mansaver Grabs in operation.

MANSAVER INDUSTRIES, INC.
3116 EAST STREET, NEW HAVEN 11, CONN.
Also Manufactured in England

PLIBRICO LINING FOR CAR HEARTH YIELDS 50% SAVINGS



The actual installed cost for completely relining the car hearth shown was cut right in half, for the one-piece Plibrico lining eliminated $1100 worth of special alloy castings required along the sides to hold the ordinary fire brick lining in place. And a troublesome operating problem was solved, too, for these expensive castings would at times warp and freeze against the furnace sides, making it difficult to pull the car at the proper temperature.

Additional savings have resulted through the lower maintenance on this securely anchored 2-component castable lining. Plicast Tuff-Lite, used for its strength and insulating efficiency, protects the bed steel, cuts radiant btu loss. Over this is Plicast Tuff-Mix with excellent resistance to abrasion and thermal shock.

You can use Plibrico refractories and methods to your advantage. See how in our catalog covering Plibrico linings for industrial, foundry, and steel mill furnaces. Send today for your copy.

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Note: Post cards expire three months after publication date.

(1) Buttweld Tubing Handbook

A "Handbook of Cold Drawn, Buttweld Mechanical Steel Tubing" has been published by Pittsburgh Tube Co. The booklet describes the manufacture, uses and economies of the buttweld product in industry. Pertinent metallurgical, mechanical and engineering data are included. The 60 pages of text and 75 photos and drawings explain each step in buttweld production, finishing and inspection, the types of product available through various mill treatments and supplementary forming operations. Buttweld parts used in industrial fabrication are illustrated at length.

(2) Equipment Catalog

The Aetna-Standard Engineering Co. has released a catalog that presents the design, research and manufacturing facilities of the company. The catalog contains full-color installation photos of their most important products, and includes a listing of their typical projects. Aetna-Standard's associated companies are discussed, a financial review, and new product ideas are also included.

(3) Drives

Reliance Electric and Engineering Co. has published a booklet describing their V*S drives. The booklet diagrams how these drives operate and how they may be applied to various types of machinery. The manufacture and functions of the drive components, including regulators, exciters, motor-generator sets, operator's panels and Super "T" motors are graphically covered. Also listed are condensed drive specifications, dimensions and accessories. (Bulletin D-2506)

(4) Graphite Electrodes

A six-page illustrated folder, published by the Electrode Div. of Great Lakes Carbon Corp., highlights recent developments in graphite electrodes for electric furnaces. The folder contains a listing of stock GLC threaded graphite electrodes and their corresponding nipples. Special data are included for Detroit furnace electrodes.

(5) Temperature Detectors

Available from Leeds & Northrup Co., is a 36-page catalog on their temperature detectors (resistance thermometers) for temperatures up to 1000 F. This new publication describes how these primary elements are being used for many applications in ceramics, chemicals, food and drugs, glass, metalworking, petroleum and refining, steam and power generation. A special section describes their precision resistance thermometers for precise laboratory work involving temperatures from −261 (12 K) to 500 C. Fully illustrated, this catalog provides a convenient, tabular listing of Thermohm specifications by application and design. A listing of accessory equipment for complete control systems and laboratory work completes the catalog. (Catalog EN-S4)

(6) Cutting Lance

"Introducing the New Oxweld ACL-3 Powder Lance" is the title of a folder published by Linde Co., Div. of Union Carbide Corp. The folder describes a revolutionary new tool capable of slicing through concrete or metal of any thickness. It also outlines the origin, principle, and scope of the powder-lancing process. Cost-saving applications in steel mills, foundries and on construction and demolition jobs are included. Complete specifications and ordering information for the lance and lancing accessories are given. (Form 1153)

(7) Industrial Motor Control Centers

General Electric Co. has available a bulletin describing their line of industrial motor control centers in NEMA sizes 1 through 6. Units of NEMA type 1 and 2 construction are also discussed. The bulletin describes features of equipment, provides data on minimum space requirements, includes planning charts and provides sample specifications. (Bulletin GEA-4979D)

(8) Aluminum Rigid Conduit

The mechanical and electrical advantages of aluminum rigid conduit are outlined in a booklet published by Aluminum Co. of America. The booklet describes the conduit and gives specific installation instructions. A comprehensive table of dimensions and weights of conduit, couplings and elbows is also included.

(9) Magnetic Flow Meters

Announced by the Foxboro Co., is a folder describing their magnetic flow meters. In addition to a description of meter features, the bulletin outlines typical "difficult" liquids which can be measured and stresses the use of the instruments in ratio flow control and pilot plant applications. Also included are full specifications, dimensions and other instrument data. (Bulletin 20-14C)

(10) Metal-clad Switchgear

Detailed information on the operation, characteristics and application of their indoor and outdoor metal-clad switchgear has been published by General Electric Co. The publication describes their

safety, compactness, maintenance and ordering ease. It includes equipment and application photos, dimensional drawings and lists of basic and optional equipment for the complete metal-clad line. Rating dimension and weight tables on indoor and outdoor units and equipment diagrams are also included. (Bulletin GEA-5664E)

(11) Shaft-Mounted Speed Reducers

Shaft-mounted speed reducers are described in a book published by Link-Belt Co. The book contains engineering and selection information on single reduction drives in six sizes, with nominal ratios of five to one and capacities up to 50 hp; and double reduction drives in seven sizes, with nominal ratios of 15 to 1 and up to 40 hp. (Book 2618)

(12) Slitting Equipment

A complete line of slitting equipment for coils and sheet stock is described in the new four-page bulletin released by E. W. Bliss Co. Also explained in the illustrated leaflet are recommended slitting procedures, including suggestions on coil handling, width of cut and use of entry and delivery pinch rolls. Design features are fully described and illustrated and capacities for standard slitters are listed in table form. (Bulletin 44-A)

(13) Mercury Vapor Floodlighting

Crouse-Hinds Co. has issued a bulletin describing their mercury vapor floodlighting. The bulletin also lists various mercury floodlights suitable for a variety of applications. Descriptions of ballasts and lamps and lighting calculations are included. (Bulletin 2696)

(14) Continuous Sleeve Flexible Couplings

A new four-page brochure containing comprehensive design and application data on newly-designed Amerigear Series GC continuous sleeve flexible couplings is now available from the Mechanical Power Transmission Div., Zurn Industries, Inc. It describes in detail how the unique combination of Amerigear's exclusive fully-crowned tooth, positive hub seals, and the new one-piece sleeve design saves money from the standpoint of lower initial costs and decreased operating and maintenance costs. Also included is a complete explanation of the many advantages new Amerigear Series GC couplings offer, proper selection data, detailed step-by-step assembly and disassembly instructions, and recommended lubrication specifications. A full page is devoted to ratings and dimensions supplemented with engineering drawings and dimensional tables of specific coupling types. (Bulletin No. 502)

(15) Heating Equipment

Steel heating equipment is described in a brochure published by Selas Corp. of America. Selas automated, high-speed furnaces are described for nearly every department of the modern steel mill: rolling mill and forge shop, foundry, strip mill, tube mill, bar and wire mill, galvanizing and tinning shops, coke-oven by-product plant and laboratory. A separate section is devoted to the heating of workpieces having heavy cross section and unusual shape. (Bulletin S-1056)

(16) Synchronous Motors and Controls

Available from Westinghouse Electric Corp., is a booklet describing their synchronous motors and controls. The brochure is completely illustrated, and contains motor selector charts, application data and formulas for calculating power factor. A quick summary of types and features of motors and controls is presented. Also included is a discussion of power factor correction, factors to consider in selecting the motor, and special application problems. (Booklet B-7297)

(17) Drives and Couplings

Dodge Manufacturing Corp. has released a bulletin describing their flexidyne dry fluid drives and couplings. Complete with product photographs and engineering drawings, the bulletin explains how this unique device solves many difficult drive problems. The bulletin includes tables to facilitate selection for normal and heavy-duty service. Operating advantages outlined in the bulletin include use of smaller motors to start heavy inertia loads, protection of motors and driven machinery against damage due to overload, low current draw at start, smoother starts, and absence of slip at normal running speeds. The bulletin also explains how speed drop and thermal cut outs (available as accessories) protect against damage in case of prolonged slippage due to overload in case of unattended installations. (Bulletin A-640-B)

(18) Stationary Batteries

C & D Batteries, Inc., have released a new two-page bulletin covering the use and design of their line of low capacity light duty lead-antimony grid batteries for control, switchgear, auxiliary power and other stationary applications. The bulletin includes complete data on the 2- and 3-cell sizes with 50 and 100 ampere-hour ratings, curves on discharge characteristics, rack data and accessory details.

(19) Crane Electrification

Aluminum inverted-Y conductor systems developed by the Cleveland Crane & Engineering Co., are described in their electrification booklet just released. The booklet covers crane and runway electrification for general industrial usage requiring currents of 500 to 1200 amperes. The equipment includes fittings and current collectors for conductor systems mounted on either wall or ceiling. (Electrification Booklet No. 1)

(20) Industrial Lubricants

Sun Oil Co.'s complete line of industrial products is described in a new booklet just released by the company. Some of the products included in the booklet are general and specialty lubricants, greases, mine lubricants, diesel lubricating oils, cutting, quenching and other metalworking oils, hydraulic oils, heat-transfer oils, rubber process aids, waxes, petrochemicals, spray oils, solvents, refrigeration oils, electrical oils and textile machine oils.

(21) Flexible Cords and Portable Cables

A booklet combining technical information and a catalog of their flexible cords and portable cables is available from the Okonite Co. The bulletin deals completely with

Okonite's line of mold-cured Okoprene (neoprene) sheathed cords and cables. The book's main divisions give dimensional data, engineering information, and splicing and terminating instructions. (Bulletin 1108)

(22) Mechanical Draft Fans

A new catalog, titled "Heavy Duty Mechanical Draft Fans," is offered by the Westinghouse Electric Corp. The eight-page brochure fully describes the company's series 7000 centrifugal fans, which are designed for handling abrasive gases at elevated temperatures. Complete application, performance and physical data are given in the catalog, as well as a list of optional accessories. (Catalog 1361)

(23) Weather Protected Motors

The Louis Allis Co. has announced publication of a bulletin on its new line of horizontal weather protected motors available in ratings from 250 to 2000 hp. Cutaway drawings in the bulletin illustrate a motor construction that is impervious to extremely high winds, driving rain, snow, sleet and sandstorms, while utilizing surrounding air for cooling purposes. Standard and special features are described, and full motor specifications given.

(24) V Belt Drives

A manual entitled, "How to Get Longer Life from V Belt Drives," has been issued by B. F. Goodrich Industrial Products Co. The manual tells how to select and install V belts, how to detect V belt trouble, diagnose belt failures, correct drive troubles. A list of valuable tips for proper V belt maintenance is included as well as a suggested inventory survey check list for V belt drives. (Catalog No. IP-1577)

(25) A-C Crane Control

A bulletin on Type "VL" crane control has been published by the Electric Controller & Mfg. Co., a Division of Square D Co. The bulletin describes in detail the components, enclosures available and applications of Type "VL" crane control. (Bulletin 6431)

(26) Infrared Heating Equipment

Hewitt-Robins, Inc. has published a booklet on infrared heating equipment for thawing frozen bulk material in railroad cars. The booklet presents a technical description of infrared heat rays and explains how they can be harnessed to speed up the unloading of materials in freezing weather. (Bulletin 168)

(27) Spherical Roller Bearing Catalog

The Torrington Co. announces the availability of one of the most comprehensive catalogs ever offered covering the design and application of spherical roller bearings. The new catalog covers five standard series of self-alining spherical roller bearings, with bore sizes ranging from 40 mm up through 1060 mm. Complete dimension tables, load ratings expressed as Basic Dynamic Capacity, and line graphs showing modifying speed and life factors help the designer to choose quickly and easily the proper bearing for each application. The design section contains detailed illustrations showing the reasons a self-alining spherical roller bearing with a center guide flange offers more desirable operating features than other types. Another section describes the company's advanced manufacturing techniques. Packaging is thoroughly explained for the purchaser who has to consider storage problems. Dimension tables for locknuts, lockplates, and push-type removable sleeves include new larger sizes not previously catalogued. Nineteen pages are devoted to general engineering information specifically related to spherical roller bearings. Such topics as bearing selection, calculating bearing life, limiting speeds, lubrication, shaft and housing fits, axial location and sealing devices are among the important subjects so thoroughly covered that auxiliary engineering text references are unnecessary. A section on typical applications is of value to experienced engineers as well as the newcomer. (Catalog 258)

(28) Cast Steels

A four-page folder detailing the chemical analyses, physical properties and comparable specifications of cast steels has been published by Farrel-Cheek Steel Co. In addition, discussions of the basic steels and products are included.

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First Class Permit No. 1963, Sec. 34.9, P. L. & R. Pittsburgh, Pa.

IRON & STEEL ENGINEER
1010 EMPIRE BUILDING
PITTSBURGH 22, PA.

IRON & STEEL ENGINEER

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NOVEMBER, 1958

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* INQUIRIES FOR ITEMS LISTED IN THIS ISSUE NOT VALID AFTER MARCH 1, 1959

PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	ADAMS CO., INC., R. P.	BULLETIN 711	Aftercoolers and separators
51	AMERICAN AIR FILTER CO., INC.	BULLETIN 248-C	Air filter
52	BABCOCK & WILCOX CO., THE	BULLETIN R-2-H	Insulating firebrick
53	BEDFORD FOUNDRY & MACHINE CO., INC.		Cranes
54	BLAW-KNOX CO.	BULLETIN 2564	Refractories
55	BLISS CO., E. W.	CATALOG 40-B	Rolling mills
56	BRISTOL CO., THE		Instruments
57	COLUMBUS McKINNON CHAIN CORP.		Alloy steel chains
58	CONE-DRIVE GEARS, DIVISION MICHIGAN TOOL CO.		Gearsets, gearmotors, speed reducers
59	CUTLER-HAMMER, INC.	EN 125-V-232	NEMA size 4 starter
60	DELAVAL STEAM TURBINE CO.	BULLETIN 2400	Planetary gears
61	EDDYSTONE DIV., BALDWIN-LIMA-HAMILTON CORP.	BULLETIN 6002	Foundry bulletin
62	ELLIOTT CO.	BULLETIN Q-23A	Equipment for steel industry and related industries
63	FARVAL CORP. THE	BULLETIN 26-S	Lubrication systems
64	FOXBORO CO., THE	CATALOG 21-10	Electronic operated measurement and control instruments
65	FRANTZ CO., INC., S. G.	BULLETIN PM-44	Magnetic separators
66	GENERAL ELECTRIC CO.	BULLETIN GEA-6812	D-c drives for metal rolling
67	HUNT VALVE CO.	BULLETIN NO. 581	Slim line valves
68	LARCO, INC.	BULLETIN AC-573	Crane cab and pulpit air conditioners (Aire-rectifiers)
69	LECTROMELT FURNACE DIV., McGRAW-EDISON CO.	CATALOG 10	Lectromelt furnaces
70	NORTH AMERICAN MANUFACTURING CO., THE	BULLETIN 1857	Shutoff valves
71	OKONITE CO., THE	BULLETIN IS-451	Portable cables
72	POST-GLOVER ELECTRIC CO., THE	BULLETIN NO. 500	Resistors
73	RADIO CORP. OF AMERICA		Industrial television
74	SELAS CORP. OF AMERICA	BULLETIN S1056	Heating equipment
75	SEL-REX CORP.		Metallic power rectifiers
76	TAYLOR INSTRUMENT COS.	BULLETIN 98175	Diaphragm manometer
77	WAGNER ELECTRIC CORP.	BULLETIN IU-226	Friction brake systems
78	WESTINGHOUSE ELECTRIC CORP.		Erosion-resisting fans

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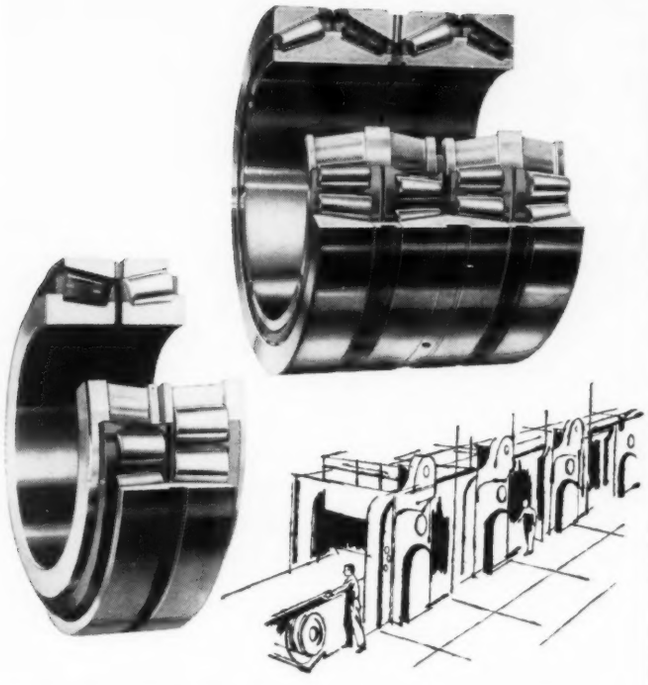

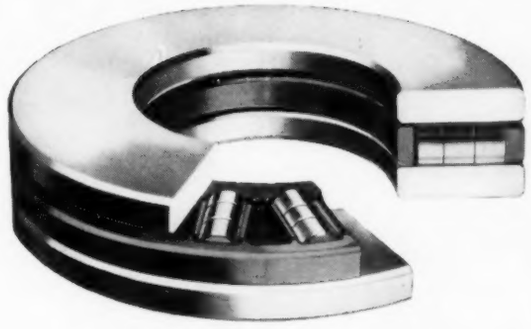

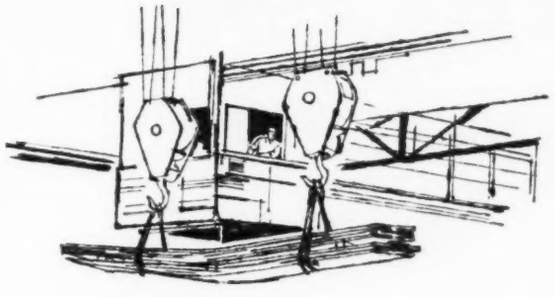

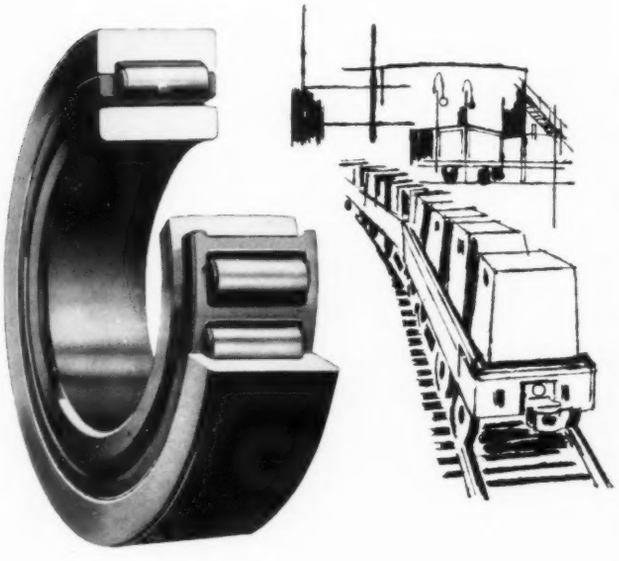

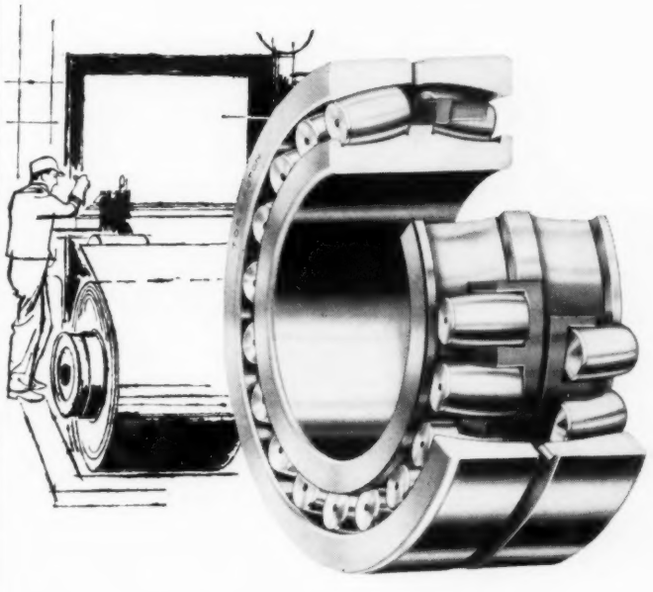

TORRINGTON BEARINGS FILL THE BILL ALL THROUGH THE MILL

Torrington offers every basic anti-friction bearing to meet specific requirements of steel mill applications . . .

TORRINGTON ROLL NECK BEARINGS, two-row and four-row, solid and pin-guided tapered roller, for every type of service in work roll, back-up roll and back-up thrust applications.

TORRINGTON ROLLER THRUST BEARINGS for mill screw downs and crane hook service.

TORRINGTON CYLINDRICAL ROLLER BEARINGS for ingot car service.

TORRINGTON SPHERICAL ROLLER BEARINGS for mill drives, runout tables, coilers, shears and other auxiliary equipment.

In every detail of design, construction and metallurgy, you'll find each Torrington Bearing unmatched for performance and service life. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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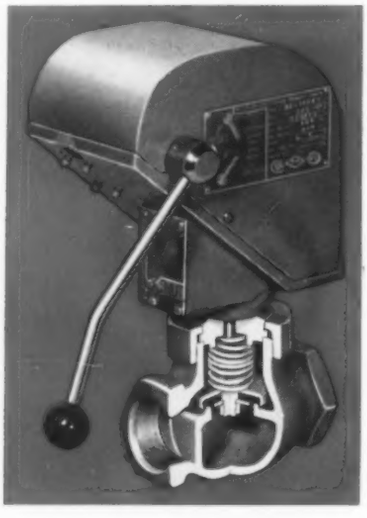
SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

MADE FOR EACH OTHER

and Your Safety

North American

Safety Shutoff Valves



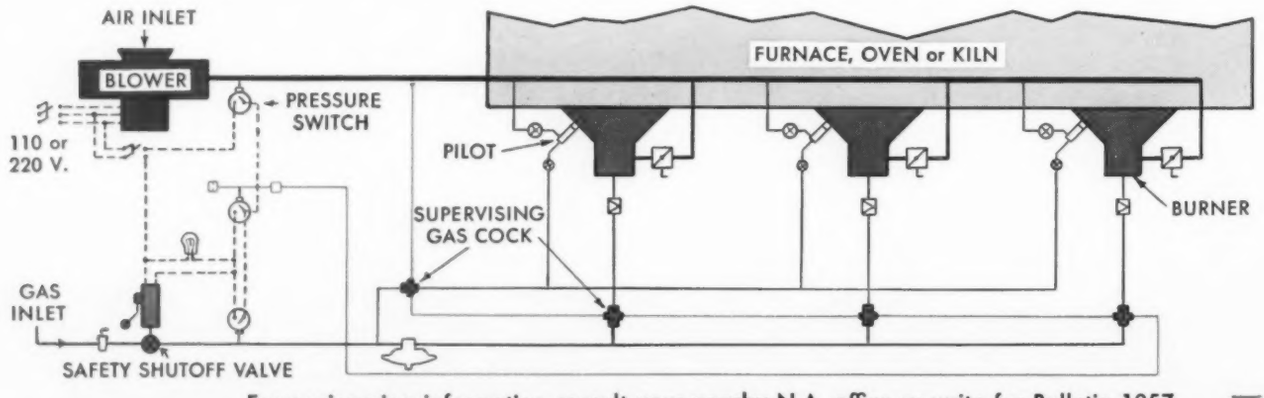
Series 22 Safety Shutoff Valves are offered in nine sizes for ¾" to 6" pipe, with solenoid or pneumatic operators, reset wheels, and companion flanges, plus provision for protection from dirty corrosive gases and weather. They are compact in design and can be installed in a variety of positions. The globe-type valve with soft seat assures positive shutoff. Approved by Factory Mutual, Underwriters' Laboratories, and Canadian Standards Association.

Gas furnace explosions sometimes occur during light-up because someone had left open a gas burner cock after the previous shut-down, thus allowing the furnace to be filled with unburned fuel. North American Series 22 Safety Shutoff Valves and Series 1857 Cocks can be combined in a Supervising Gas Cock System to prevent such explosions.

The Series 1857 Supervising Cock is drilled with a small secondary passage located so that it is open only when the main passage is closed. A checking pressure line is connected through the secondary passages of all the Supervising Cocks so that a pressure switch at the end of the line cannot close a circuit to the safety shutoff valve until all the cocks are shut. If the operator finds that he cannot open the safety shutoff valve, he must locate the open Supervising Cock and close it.

and Supervising Gas Cock Systems

Series 1857 Supervising Gas Cocks are offered in fourteen sizes for ¼" to 6" pipe.



For engineering information consult your nearby N.A. office or write for Bulletin 1857.

The North American Manufacturing Co.
COMBUSTION ENGINEERS
CLEVELAND 5, OHIO

NORTH AMERICAN COMBUSTION Since 1917

18.57

Personnel News...

John B. Hill was appointed technical assistant, blast furnace operations, in the Steel Division of Bethlehem Steel Co. at Bethlehem, Pa. **Edward Ball** was appointed to Mr. Hill's former post as superintendent of blast furnaces at the company's Lackawanna, N. Y., plant. **Charles W. Felton, Jr.,** was named assistant blast furnace superintendent to succeed Mr. Ball.

Emil A. Vierow has been appointed assistant to the manager of the Youngstown district of the Youngstown Sheet and Tube Co. Mr. Vierow joined the company in 1944 as superintendent of the fuel department and in 1953 became superintendent of fuel and power. Before joining Youngstown, Mr. Vierow worked in the fuel department at the Pittsburgh works of the Jones & Laughlin Steel Corp., where he became assistant fuel engineer. Later, he served as fuel engineer for the Alan Wood Steel Co., and as chief fuel engineer for the American Steel and Wire Co.

Robert T. Eakin was named vice president of operations, Latrobe Steel Co., Latrobe, Pa. He was formerly plant manager, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

H. Kermit Fish was named electrical superintendent and **A. W. Jurvic** assistant electrical superintendent at Weirton Steel Co., division of National Steel Corp. Mr. Fish began his employment with Weirton in 1924 as a wireman helper and the next year became an electric repairman in the Steel Works electric repair gang. In 1927 he was named electric construction foreman in the 48-in. Strip Steel (later to become the 54-in. Strip Steel) and in 1928 was appointed electric repair foreman for the Strip Steel Departments. In 1945 Mr. Fish was promoted to assistant general electrical foreman in the Strip Steel Departments and a year later was advanced to general electrical foreman. In 1953 he was appointed assistant electrical superintendent, Service and Maintenance Department, and held that position until his current appointment.

Mr. Jurvic, who succeeds Mr. Fish as assistant electrical superintendent, became associated with Weirton in 1933 in the Open Hearth Department. In 1938 he was appointed to the newly-created meter and relaying department. In 1945 he was appointed electrical field engineer in the Service and Maintenance Department. In 1952 he was advanced to electrical engineer and held that position until his current appointment.

McKnight Kinne has been appointed assistant to the director of general purchasing of Armco Steel Corp. Mr. Kinne joined Armco in 1937 as a laborer. In 1939, he was made a correspondent in the sales department.

In 1947 he was named staff assistant for Armco Drainage & Metal Products, Inc. He was transferred to the purchasing department in 1950.

Robert A. Solborg was named management representative in Europe, with headquarters in Paris for Patterson-Emerson-Comstock, Inc. In October, 1957, Mr. Solborg retired as vice chairman of Armco International Corp., in charge of European operations and as president of Armco S A, its European subsidiary corporation. Since then, he has continued his affiliation with that company as a consultant.

Robert J. Roberts has been appointed as assistant to the general superintendent of Weirton Steel Co., division of National Steel Corp. In his new capacity Mr. Roberts will handle special assignments for the operating departments. Before joining Weirton he held various posts with United States Steel Corp.

James L. Daniell has joined Jessop Steel Co. as executive assistant to the president. He formerly was vice president and general manager of Alloy Manufacturing Co., Inc.

Eugene V. H. Ross, field service engineer, retired from A. M. Byers Co. September 1, after 28 years of service. **Calvin L. Wright** has been appointed to succeed Mr. Ross in the Baltimore district.

W. A. Black has been appointed assistant director of research of Republic Steel Corp. in charge of all activities at the Electro-Mechanical Research Center

J. B. HILL

EDWARD BALL

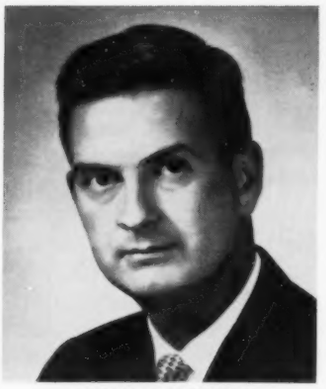
E. A. VIEROW

R. T. EAKIN

W. A BLACK

D. J. ENOCHS

ERNEST WILLISON



W. W. MOORE

at Cleveland, Ohio. He was previously chief engineer of the Steel and Tubes Division. Mr. Black joined Republic as a research engineer in 1929. In 1935 he was named chief electrical engineer of the Steel and Tubes Division.

David J. Enochs has been placed in charge of company-wide raw materials engineering for Armco Steel Corp. Mr. Enochs has been serving as raw materials engineer for the Armco Division of the company since 1957.

Ernest Willison has been appointed engineering manager for Engineering Works Division of Dravo Corp. **Donald A. Booth** has been promoted to assistant engineering manager.

William W. Moore has been elected vice president for sales and a director of Research Cottrell, Inc. Mr. Moore joined Research-Cottrell, Inc., as an operations and service engineer in 1946. He became an estimator in 1947, a sales engineer in 1950, and was New York district sales manager from 1953 until his present election.

John A. Mahoney, Jr., was named sales engineer by Pangborn Corp. Mr. Mahoney will be headquartered at the Philadelphia district office of Pangborn. He was previously associated with Reeves Pulley Co. in Philadelphia as a sales engineer.

Samuel W. Gearhart, Jr., has been promoted to chief metallurgist at Birdsboro Steel Foundry & Machine Co. from his former position of metallurgical consultant and sales engineer. He joined the company in 1956 as sales and service engineer after serving nine years as metallurgist and supervising metallurgical engineer for Baldwin-Lima-Hamilton Corp., Eddystone Division.

C. H. Rahenkamp, Jr., has been appointed representative in charge of the newly opened Pittsburgh Pa., sales office of the Trumbull Bronze Co. Mr. Rahenkamp was previously with United States Steel Corp.

Don B. Hooser has been appointed Southern district manager of the Cleveland Tramrail Division, The Cleveland Crane & Engineering Co. He succeeds **William P. Hanks** who now is Midwestern district manager.

Norman F. Garrett has been elected vice president and general manager for manufacturing of Crane Co. Mr. Garrett has been general manager of the company's Chicago manufacturing division since January, 1957.

H. Yale Mageoch, formerly manager of the Electric Service Works of Delta-Star Electric Division, H. K. Porter Co., Inc., was made director of engineering and research for the Division, with headquarters in Chicago. He had previously served as chief engineer of the Works.

R. W. Dixon, formerly assistant manager of the Electric Service Works of Delta-Star Electric Division, H. K. Porter Co., Inc., has been appointed manager of the Electric Service Works in Philadephia, Pa. He was chief engineer, vice president, and active in other management positions with Electric Service Engineering Co. before its purchase by the Porter organization in 1955.

H. Y. MAGEOCH

R. W. DIXON

The overwhelming majority of cranes and pulpits being equipped with air conditioning are Lintern equipped.

The reasons for this are contained in our 20-page Bulletin AC-573 which describes Aire-Rectifiers for each temperature range of cab, also models for pulpits.

Write for copy today.

Larco, inc.

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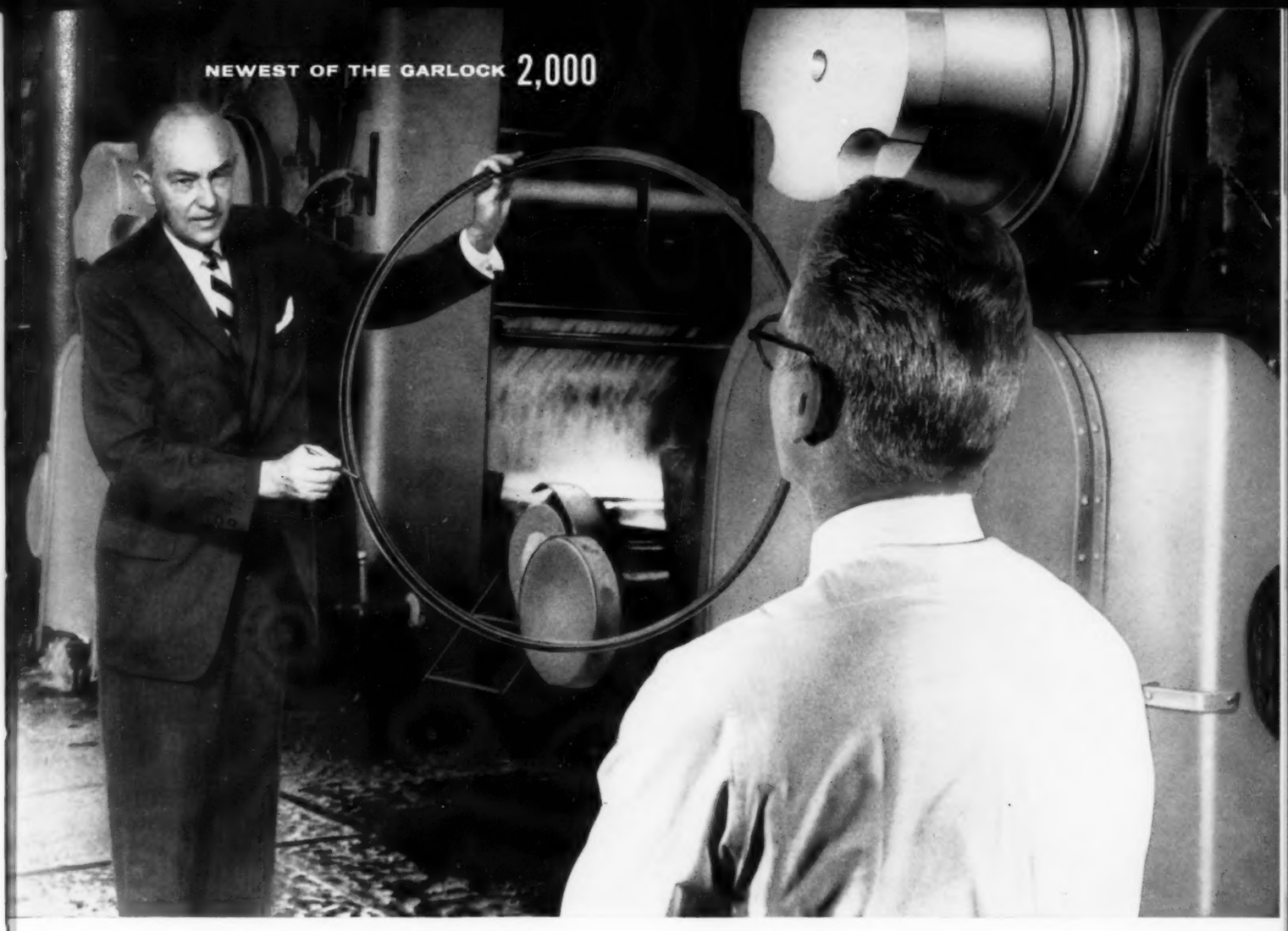
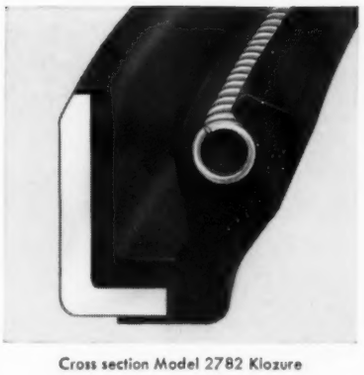


Garlock introduces new low cost KLOZURE* Oil Seals for large shafts

Here's a new KLOZURE Oil Seal that will save you money on initial installation and replacement. It's the new Model 2782 Garlock KLOZURE for large shafts up to 44" diameter operating at normal to high speeds, at temperatures to 275° F., on applications with low pressure differentials of approximately 5 psi. A garter spring holds the Buna-N sealing element in contact with the shaft. A precision formed case molded to the sealing element protects the seal from damage, and provides a press fit for proper installation.

Selection of a KLOZURE Oil Seal for your job is easier and more economical because Garlock has one of the largest stocks in the industry. And KLOZURES, of course, are just a part of the famous Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. The *only* complete line. Ask your local Garlock representative for his unbiased recommendation, or write for additional information on the Model 2782 KLOZURE.



Cross section Model 2782 Klozure

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Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Be Right . . . Buy Bearings By ALL the Numbers . . . from Bearings, Inc.

It is not enough to buy bearings by the bearing number alone! Those prefix and suffix numbers often determine bearing success or failure. Cost, too, is determined by those numbers for they show degree of precision, internal clearance and the amount of preloading.

How can you always make sure you get the right bearing for every application? It's simple! Contact our nearest branch and we will deliver bearings in the manufacturer's original sealed box. Every bearing is guaranteed by the maker and ourselves to be as specified on the box. Each bearing will be "factory-fresh" to give you best possible performance and life. Our representatives are qualified to assist in determining correct precision and fit on all bearings in your equipment.

Providing bearing service in the North ➤ **BEARINGS, INC.**

OHIO: Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Lockland • Mansfield • Toledo • Youngstown • Zanesville
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WEST VIRGINIA: Charleston • Huntington • Parkersburg • Wheeling • **NEW JERSEY:** Camden
NEW YORK: Buffalo, Balanrol Corp. • **MARYLAND:** Baltimore • **DELAWARE:** Wilmington

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R. H. GEHRIG

R. B. BERKEY

J. F. HORNOR

R. W. FOX

R. H. Gehring, former sales engineer in the Pittsburgh territory for Larco, Inc., was named sales manager of Industrial Products in the home office at Painesville, Ohio. Mr. Gehring is succeeded in Pittsburgh by **R. B. Berkey.**

Joseph F. Hornor has been appointed by Brown Instruments Division of Minneapolis-Honeywell Regulator Co. as market manager for the metals producing and ceramic industries. Joining the division in 1950, after eight years with Corning Glass Co. as glass technologist and assistant superintendent of melting, Mr. Hornor served as an application engineer prior to his present assignment. He succeeds **John R. Green,** who has retired.

R. W. Fox was named central region manager of the Elliott Co. He has been the Cleveland district manager for 17 years. **M. C. Seeman** succeeds Mr. Fox as Cleveland district manager.

Walter M. Northey was named general superintendent of Gulf States Tube Corp., subsidiary of Michigan Seamless Tube Co.

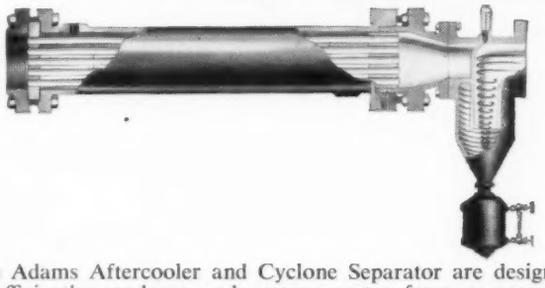
Harold D. Esterly, former assistant superintendent, electrical maintenance, blast furnace and coke and chemical departments, Alan Wood Steel Co., retired August 31.

Obituaries

James S. Freese, 54, general production manager of the Timken Roller Bearing Co., died October 13.

Robert Wallace Nelson, 48, vice president of American Air Filter Co., died October 9.

Aftercooler and Cyclone Separator designed for cleaner, dryer compressed air



The Adams Aftercooler and Cyclone Separator are designed to efficiently condense and remove water from compressed air and process gas. Condensed moisture and entrained dirt and oil are subsequently removed in a cyclone type separator. This unit is scientifically designed for maximum removal efficiency over a wide range of flow rates.

For normal use, units are available to cool gases to within 10° F of the temperature of the cooling water. Specially designed units are available to permit a 2° F approach to cooling water temperature, for application where low moisture content is critical.

Adams Aftercoolers and Separators are available from stock to handle 20 - 40,000 cfm with 10° cooling and 25 - 19,200 cfm where it is necessary to cool within 2°F of the cooling water. Special units can be supplied to suit an unlimited range of requirements. In all cases the maximum pressure loss at rated capacities is ½ psi.

This wide range of sizes enables the economical utilization of Adams Aftercoolers and Separators in virtually all industrial application. For further information on how R. P. Adams' units will solve your compressed air problems and save you money, write today for Bulletin 711. R. P. Adams Co., Inc., 223 East Park Drive, Buffalo 17, New York.

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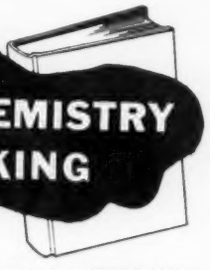
THE PHYSICAL CHEMISTRY OF STEELMAKING



Proceedings of the Conference on THE PHYSICAL CHEMISTRY OF IRON AND STEELMAKING, Endicott House, Dedham, Mass., May 28 to June 3, 1956. Edited by JOHN F. ELLIOTT, Massachusetts Institute of Technology.

Papers presented at this Conference sponsored by the Department of Metallurgy, M.I.T., summarize the thinking of outstanding metallurgists to give you a better understanding of actual steelmaking systems. Includes results of the latest research in the field, and shows how this research can be applied to current technical problems.

In nine information-packed sections:

- Liquid Metals and Properties of Solutes in Liquid Iron and Steel
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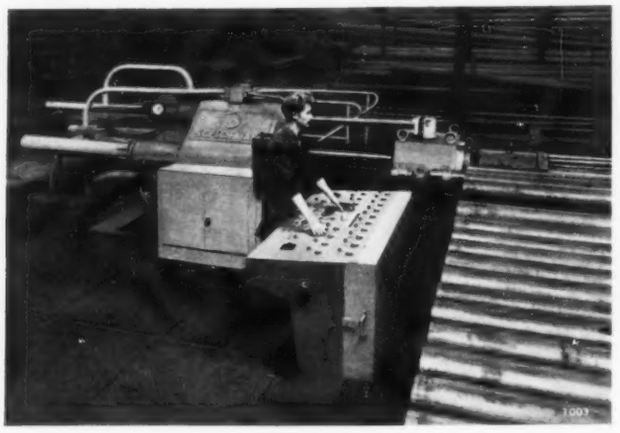


Electric control desk. At left, hydraulic control cubicle with testing time and pressure recorder, testing pressure tele-setter, and control gauges.

Fully automatic tube tester

In addition to automatic five-tube and two-tube testers for tubes of small and medium diameters, SCHLOEMANN also builds fully automatic single tube testers for tubes with big diameters and for high testing pressures. All these testers have proved themselves in continuous operation.

Technical data

Tube o.d.	3½ in. to 7 in.
Lengths of tube	15 ft. to 46 ft.
Testing pressure infinitely variable	1,000 PSI to 7,100 PSI
Maximum sealing force	100 tons
Operating pressure	1,000 PSI
Maximum prefill water pressure	170 PSI
Output per hour obtained so far	
3½ in. to 4¾ in. dia., 7,100 PSI	180 tubes
4¾ in. to 7 in. dia., 5,200 PSI	120 tubes

Features and advantages

● The frame-type design is accessible on three sides and requires only simple foundations. The testing operation can be fully viewed, and the tubes are passed quickly through the press.

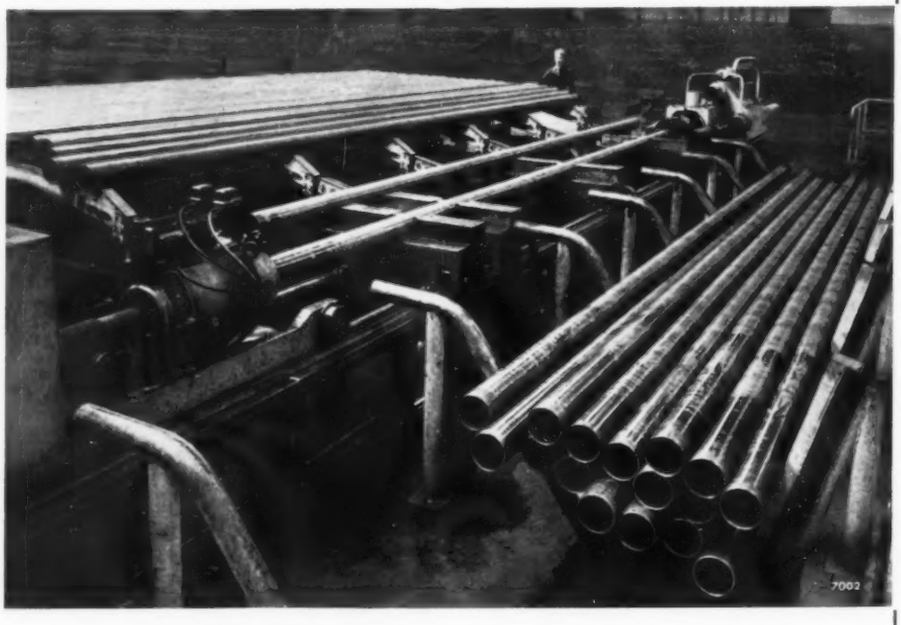
● The counter-crosshead and the clamping and supporting carriages can be traversed and locked on the frame. They adapt themselves automatically to the actual tube length. In each locking position, differences in tube lengths up to 79 inches can be compensated by automatic traversing of the tester heads by means of a pressure spindle and/or hydraulic piston.

Tube tester seen from the delivery side. At left, traversable counter-crosshead with pressure spindle; opposite, stationary crosshead with hydraulic traversing piston; in-between, clamping and supporting carriages.

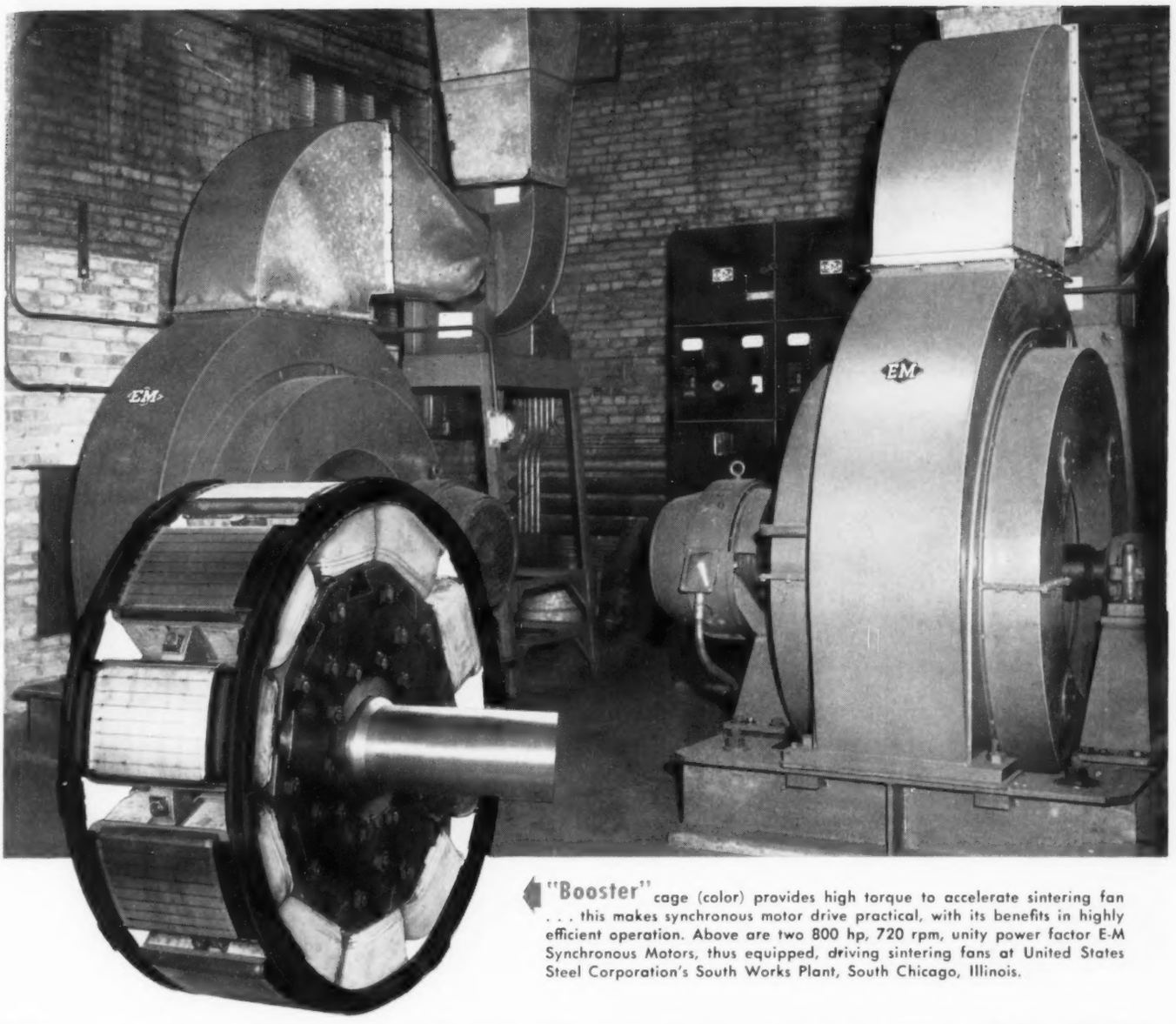
● Sealing of the tube ends is effected in universal tester heads by high-pressure packings for the customary types of tube. The special design of the tester heads assures these a long packing life.

● All electro-hydraulic controls are located below floor level and are easily accessible.

● One man operates the entire tube testing installation. The main and auxiliary equipment of the press can be individually controlled for checking. Normal operation is fully automatic, so that the operator can give all his attention to the tube undergoing pressure.



FELLER ENGINEERING CO., 1161 EMPIRE BUILDING, PITTSBURGH 22, PA.



"Booster" cage (color) provides high torque to accelerate sintering fan . . . this makes synchronous motor drive practical, with its benefits in highly efficient operation. Above are two 800 hp, 720 rpm, unity power factor E-M Synchronous Motors, thus equipped, driving sintering fans at United States Steel Corporation's South Works Plant, South Chicago, Illinois.

How to drive a sintering fan most profitably

● There are sound reasons why synchronous motors (such as the installation above) are the most economical sintering fan drives. Consider your power bill . . . the high efficiency of the synchronous motor produces maximum usable horsepower from a minimum of electric power. Your entire electrical system will benefit from power factor improvement through the unique ability of synchronous motors to correct lagging power factor. You save on power costs both ways. And motor maintenance costs are low too.

However, the fans have a large WK^2, and sintering begins with a cold bed. So, E-M engineers developed a special double-deck starting cage for these difficult starting and synchronizing requirements. Here's what it does:

Characteristics of this E-M extra-heavy-duty double-cage winding are such that uniformly high torque is provided for both starting and pull-in. This E-M winding not only accelerates the heavy fan, but also provides that powerful "boost" to 98½ % of synchronous speed needed to pull it into step.

Further assurance of powerful synchronizing is offered by the E-M-invented Polarized Field Frequency Control which automatically applies field excitation at the instant when rotor angle will give maximum synchronizing power with no pole slippage. Current inrush is held at a minimum.

E-M's pioneering and long experience in synchronous motor applications have resulted in many profitable steel plant installations. Ask your nearest E-M sales engineer for his practical suggestions on your requirements.

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

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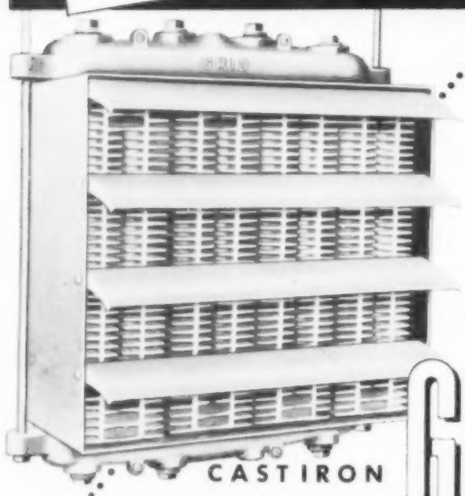
Specialists in making motors do
EXACTLY WHAT YOU WANT THEM TO

Corrosion in heating equipment Ends



when you install GRID

CAST IRON STEAM HEAT TRANSFER SURFACE

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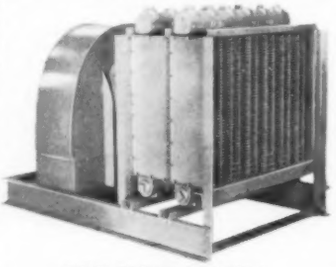
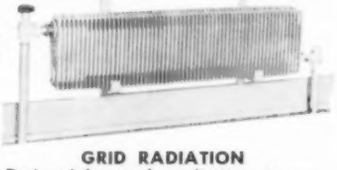
You once and for all eliminate internal electrolytic corrosion because all metals in GRID Cast Iron Steam Heat Transfer Surface that are in contact with steam are similar . . . not 2 or 3 different metals that promote corrosion to cause leaks and breakdowns. GRID Cast Iron Steam Heat Transfer Surface also eliminates external corrosion because its cast iron construction resists acids or fumes in the air. When corrosion in heat transfer equipment ends, maintenance ends . . . it's as simple as that, no mystery, no magic, no "sales" talk. Your heating problems are no longer problems . . . you do away with high maintenance costs, repair work and the nuisance of leaky heating equipment.

GRID Cast Iron construction eliminates the use of reducing valves where high steam pressures are used. It is designed to withstand steam pressures up to 250 P.S.I. . . . 450° temperature. GRID Cast Iron Steam Heat Transfer Surface does away with replacement costs because GRID is built to last for years . . . operating successfully without maintenance in many plants since 1929. Sounds worth looking into? Then get the complete story today . . . come the heating season, you will be glad you did.



GRID BLAST HEATERS

Shown in fan assembly . . . rugged, strong and economical heat transfer surface designed for the tough job . . . for low and high steam pressures . . . requires less labor for installation and less cubical space.



GRID RADIATION

Designed for tough applications in conjunction with high steam pressure systems, GRID Radiators eliminate the use of pressure reducing valves . . . will withstand steam pressures up to 250 P.S.I. . . . adaptable for factory, shop offices, store rooms laboratories, etc.

Send for the complete story on GRID Unit Heaters, GRID Blast Heaters, and GRID Radiation for steel plant use . . . it is contained in GRID Products Catalog No. 956. Write today for your copy.

D. J. MURRAY MANUFACTURING CO.

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out of Lubricating Oil . . . and Hydraulic Fluid . . . Minimize Cost of Maintenance and Delays

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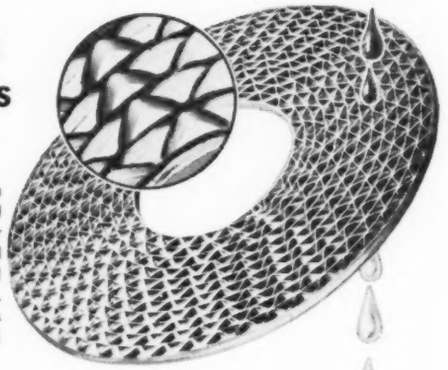
FERROFILTER GRID (right) . . . one of a strongly magnetized stack with 100's or 1000's of feet of grid edges which catch and hold finest iron particles. Magnified inset shows ferrous grit collected on grid edges.



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Model PO-6 for 3" pipe line available with screwed or flanged connections. Other sizes from 3/8" to 8"r

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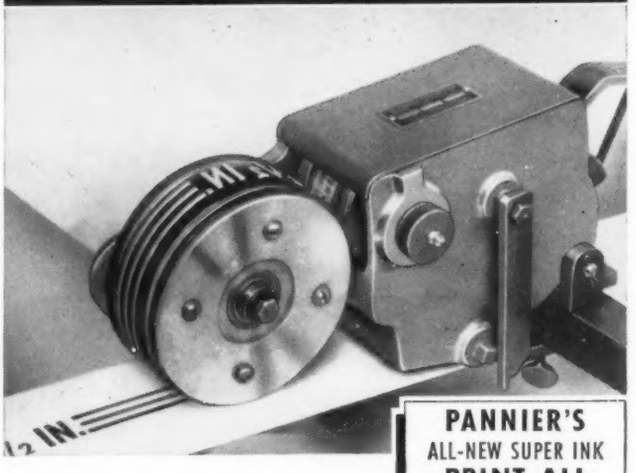

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Internally fed unit.
Use inks from semi-paste to liquid, including light colored, heavy pigmented inks.
Continuous or repeat printing.
No stopping to add ink.
Print on 1" centers with multiple staggered units.

Super Ink Print-All clearly marks all conveyed materials traveling horizontally or vertically. It prints top or bottom surfaces as material moves under or over the printer.

Write for complete data.

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Your NATIONAL TRADE-MARK brush man showed this electroplater how to double brush life!

CLIFF BROWER

Rapid brush wear was limiting generator performance at this busy electroplating plant, says "National" Carbon Brush Man, Cliff Brower. No other industrial brush solved the problem until Cliff suggested a newly developed "National" brush grade.

That was five years ago. Since then not one commutator has been stoned or turned. Brush wear has been even, with no selective action or overheating—even under 20% overloads. This "National" BGX brush grade actually doubled brush life.

Cliff Brower and his fellow "National" Carbon Brush Men have been solving industrial brush problems for years. Their experience and training—backed by "National" *long term brush development*—make them the best consultants on any industrial brush problem.

Call your "National" Brush Man today. Or write National Carbon Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N. Y.

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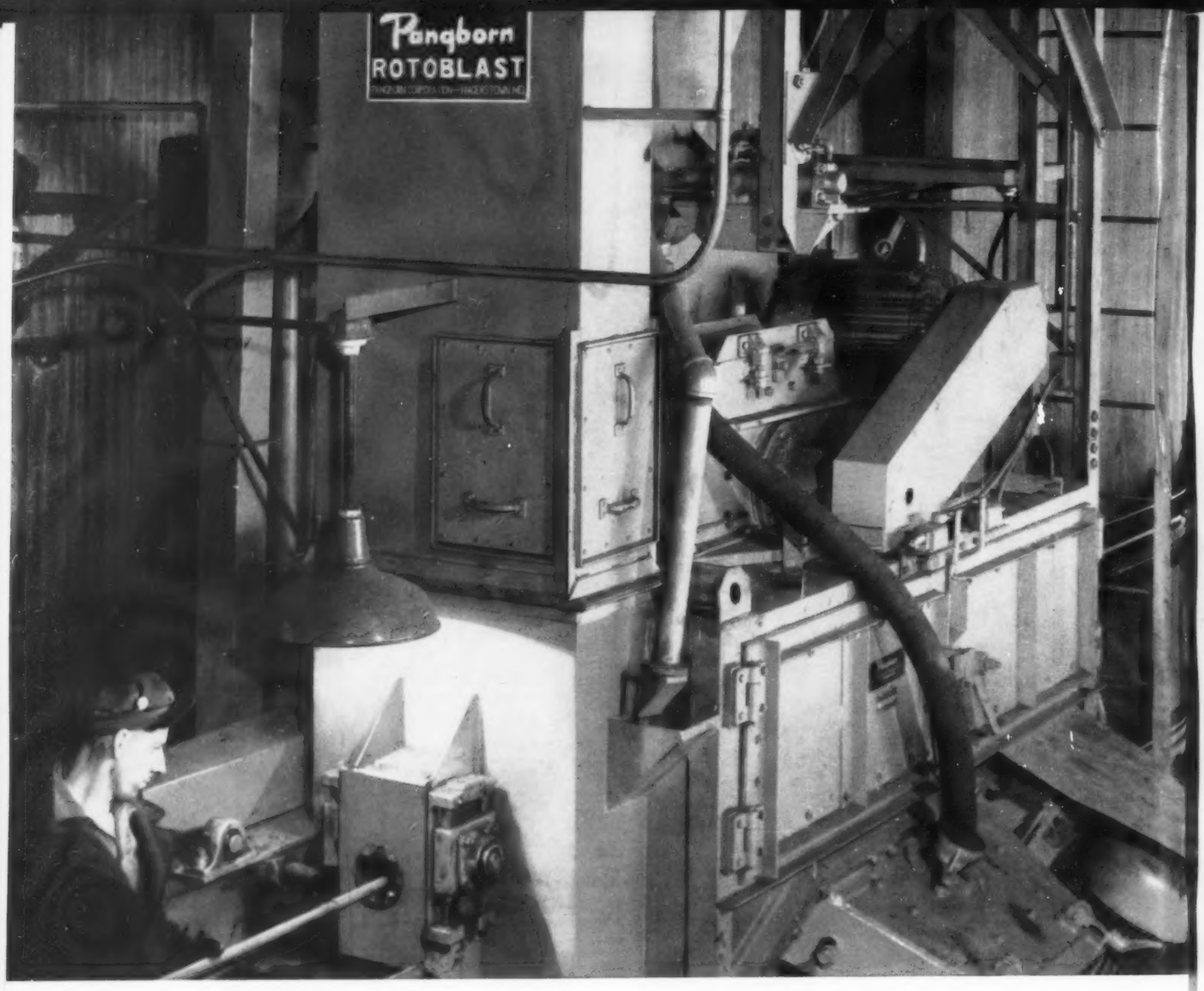


High-speed Pangborn Rotoblast Descaling Machines eliminate pickling, permit automation in wire drawing!

THOROUGH . . . Rotoblast descaling eliminates the need for pickling . . . rod can be drawn without further cleaning.

WORKABLE . . . Rotoblasted finish provides excellent base for lubricant or drawing compound, fine bonding surface for coating.

VERSATILE . . . Pangborn Descaling Machines handle cut lengths or coils, designed for single or multiple strand descaling.

LOW-COST . . . Operating costs and manpower requirements are held to a minimum.

CONTINUOUS . . . These machines eliminate multiple handling necessary for batch descaling and coating operations, fit into fully automated wire drawing production line.

FOR DETAILS . . . talk to your Pangborn district engineer or write PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Maryland.

Clean it fast with

Pangborn ROTOBLAST®

Equipment News...

COIL ROTATING UNIT

△ A floor mounted rotating device to facilitate the handling of coils with fork and ram type lift trucks and increase the number handled in a production day has been developed by Yale Materials Handling Division, The Yale & Towne Manufacturing Co.

The new device was designed in co-operation with materials handling engineers of the American Can Co., to work in conjunction with Yale K-48 fork and ram trucks to supply a revolutionary, new coil line can-making technique. The rotator, or upender, permits the easy utilization of coils of steel or other metal received in palletized form.

Palletized metal coils are placed on the bed of the rotator by a Yale K-48 truck with special ram forks hydraulically separated to accommodate the pallet.

The truck is then backed a short distance to a conveniently located overhead control pendant which activates the upender. Pressing an automatic cycling button causes two arms with wide pads to close around the forward circumference of the coil. A third arm then moves in from the rear to assure positive support to the coil.

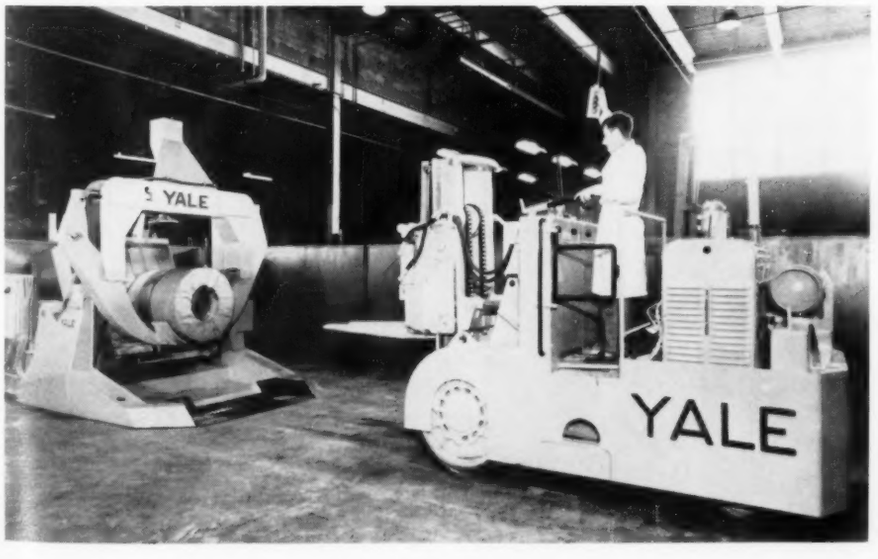
With the coil firmly grasped, a pressure sensing switch causes the upender bed to rotate forward until the coil is in a vertical position, supported by the arms and pads. When the coil reaches this position, the stabilizer arm is withdrawn and the bed with the loose pallet is canted to the rear so that it will not interfere with the removal of the coil.

The truck operator then closes his forks to form a single ram, moves forward and picks up the coil with the ram for delivery to a manufacturing operation.

As he backs away from the rotator he pushes another control button on the pendant which returns the rotator bed to a horizontal position and opens the arms ready to receive another palletized coil.

Reversing this procedure permits use of the unit as a palletizing mechanism for coils.

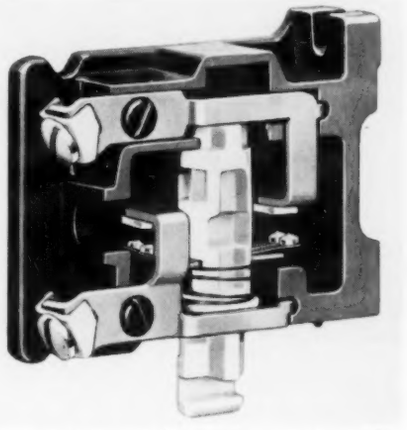
The new Yale coil rotating device is shown on the left after having turned a palletized coil of steel from a horizontal to a vertical position. The operator of the ram fork truck controls the device from an overhead control pendant.



METAL CONTACT POLES

△ Individual poles with noble metal contacts, to enable one or more poles of rugged industrial control relays to be used in electronic and instrumentation circuits, have been developed by Clark Controller Co. This enables grouping of electronic and standard control circuits for actuation by the same magnet. The new noble metal contact poles are available normally-open or normally-closed, and may be used on any of the relays in Clark's Type "PM" line, including convertible-pole relays, universal-pole relays, time-delay relays and latch relays.

The new poles have contact tips of a palladium-ruthenium alloy, a hard material with a high melting point, which is highly resistant to corrosion and tarnish and does not form a stable oxide. These



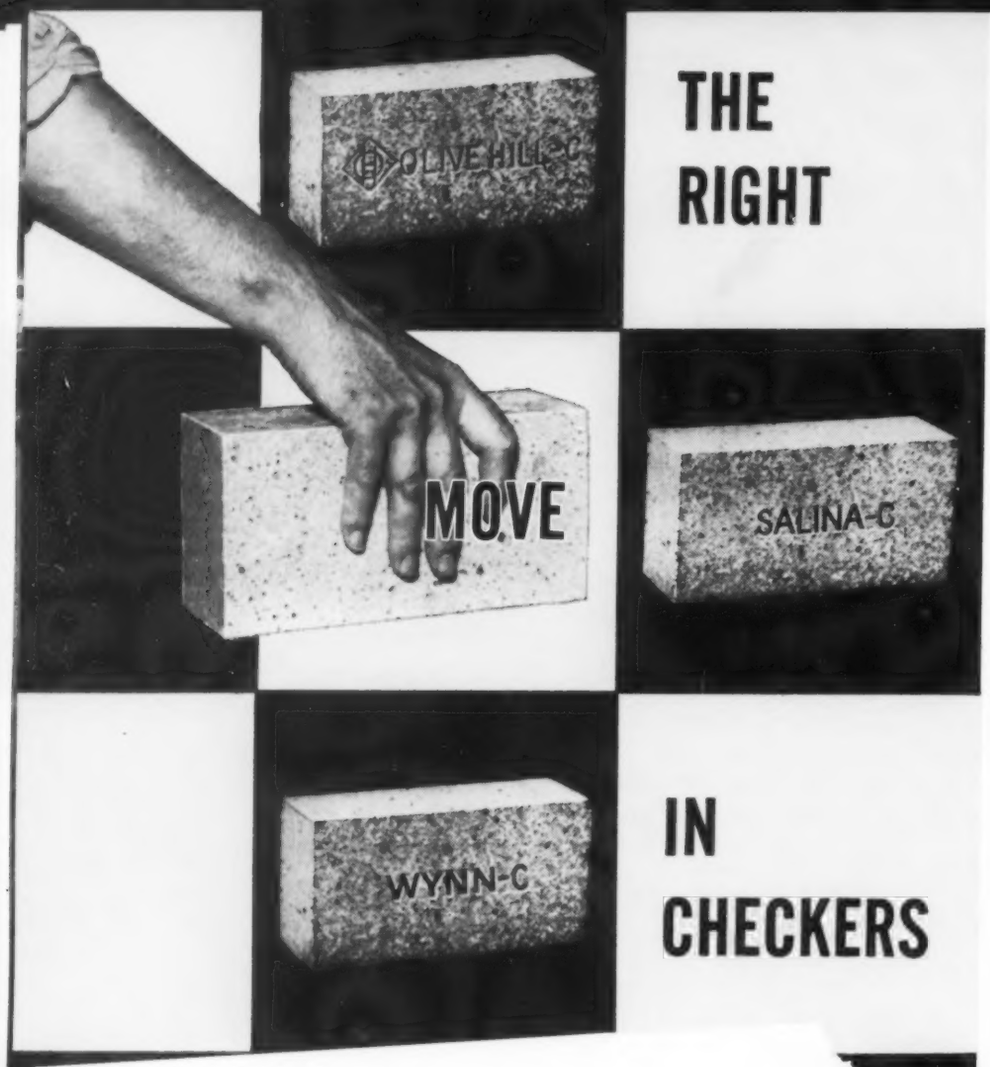
properties, and wiping action designed into the contact motion, make it unnecessary to depend upon arcing to break down contact surface resistance. Thus these poles can be used in high impedance and low voltage circuits which produce little or no arcing. They are recommended for use in circuits of up to 600 volt, drawing 0.5 volt-amperes or less.

The new poles are mounted in individual melamine blocks, which may be installed in place of existing poles, in the field, without disturbing other poles on the relay or their wiring.

The new noble-metal-contact poles offer to circuit designers the convenience and flexibility of switching standard 10-amp industrial control circuit and electronic control and instrumentation circuits with the same relays.

BALL ACTUATED VALVE

△ Newly introduced by Hunt Valve Co. is a ball actuated spring



THE RIGHT MOVE IN CHECKERS

General Refractories offers **superior** high duty fireclay checker brick; possessing all four properties recognized as the criteria for long life in regenerator chambers — high density, low porosity, high strength and refractoriness.

High density and low porosity are needed to insure volume stability, optimum heat transfer and minimum penetration of flux-bearing gases. High refractoriness, coupled with these other properties, is needed to withstand the temperatures prevalent in most regenerator chambers.

Any one of these properties by itself cannot describe an excellent checker. It is the combination of all these properties in one product that produces a superior checker brick.

GREFCO checker brick possess ***all*** these attributes. Manufactured from select, highly refractory fire clays; by GREFCO's unique double-tempering process; pressed in special dual-action, deairing power presses, fired to high temperature in tunnel kilns; and given a final rigid inspection for accurate size and quality; General Refractories' "C" brands are superior checkers.

Surely, "THE RIGHT MOVE IN CHECKERS" is to — GREFCO!

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GENERAL REFRACTORIES COMPANY
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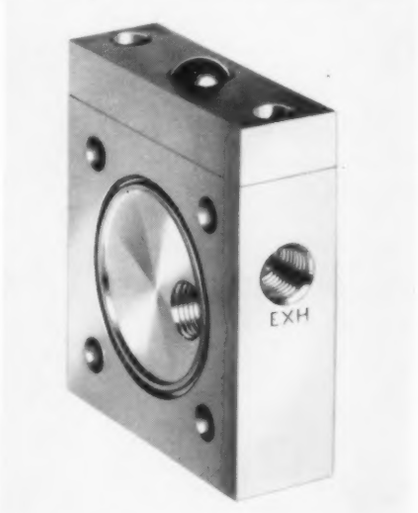
return valve, only 1 in. thick and 3 in. wide. These valves are streamlined in appearance, and can be mounted easily on machines and machinery even when space is extremely limited. They are designed for air, oil or water service; pressures to 125 psi; temperatures to 150 F. The valves are furnished tapped for either $\frac{1}{8}$ in. or $\frac{1}{4}$ in. pipe connection.

These valves can be adapted to a multitude of mechanical applications, and have many advantages over typical cam operated valves due to the flexibility of mounting; the elimination of complex links and other operators. The ball actuator



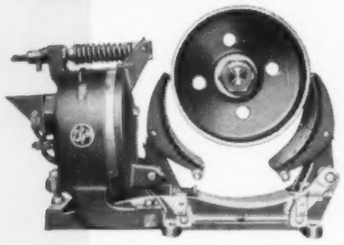
can be depressed from any peripheral point of 360 degree as long as the valve plunger is given its full $\frac{1}{8}$-in. travel; $\frac{1}{32}$-in. over-travel is provided. They are furnished in 3-way "Normally Closed" or "Normally Open" and 4-way actions.

The valve housing is milled from solid aluminum bar stock. The valve chambers, in the straight through bore, are formed with metal spacers held rigidly in metal to metal end abutment. The spacers support and accurately position the "O"-ring seals. The stainless steel valve plunger is hollow and radially ported.

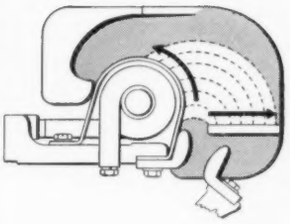
The valves can be manifolded together easily and quickly without requiring any special parts. The side of the housing of each valve is counterbored $1\frac{3}{4}$ in. in diam, and 0.055 in. deep; trepanned for an "O"-ring; and provided with four through holes, thus permitting the valves to be manifolded together in any of four 90-degree angle positions. Line air passes through each valve, permitting eight valves to be

It's EC&M for a Complete Line of ELECTRIC CRANE CONTROL

BRAKES · DISCONNECT SWITCHES · CONTROLLERS · LIMIT STOPS

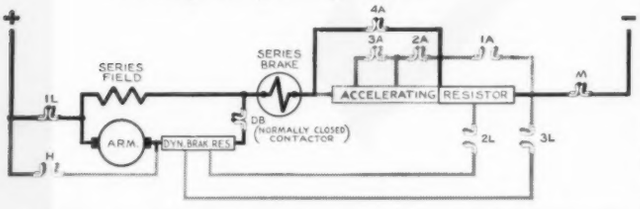


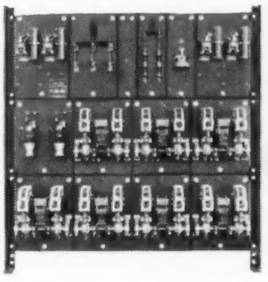
LONG-LIFE BRAKES for cranes operated by A.C. or D.C. power. High speed performance. Low upkeep.



CONTACTORS operate on the LINE-ARC principle. No destructive burning of arc shields. Cool contacts and reduced maintenance.

DYNAMIC LOWERING CIRCUITS for hoist motions. Respond quickly. Permit accurate inching for spotting loads.

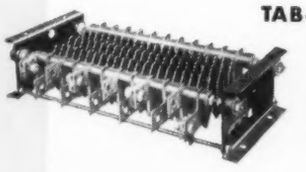




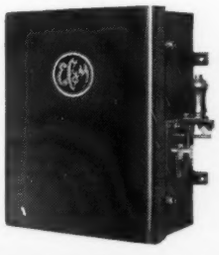
REVERSING-PLUGGING CONTROL for bridge and trolley motions. Automatically controlled acceleration. Only one simple relay for plugging.

YOUNGSTOWN SAFETY LIMIT STOPS protect against overhoisting accidents. Positive check against human errors.

CAM-TYPE MASTER SWITCHES have narrow width and short throw. Less operator fatigue.



TAB-WELD PLATE RESISTORS —spot-welding provides a continuous path, and keeps resistance value constant.



MANUAL-MAGNETIC DISCONNECT SWITCHES are very easy to operate. They are arranged to control crane lights, too.

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A DIVISION OF THE SQUARE D COMPANY

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QUALITY CONTROL

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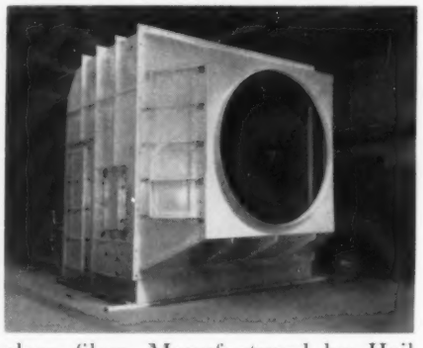
Taylor Made CHAIN SINCE 1873

operated simultaneously from a single supply, or up to sixteen valves simultaneously from two supply lines.

PLASTIC FUME WASHER

Photo shows one of the largest solid plastic structures ever built for handling and scrubbing chemical corrosive fumes. Washer is 12 ft high and has a 7-ft diam outlet, and was constructed of a special epoxy formulation reinforced with



glass fiber. Manufactured by Heil Process Equipment Corp., this equipment is used principally for sulphuric acid contaminants. An advantage in the all plastic construction is that it requires no painting or maintenance in the portions exposed to outside weather; its light weight enables placement on roofs without exceeding roof-loading limits.

CIRCUIT BREAKERS

△ Individually enclosed models of its new K-line low-voltage power circuit breakers have been introduced by the I-T-E Circuit Breaker Co.

The metal enclosed U-Re-Lite models offer many new safety features plus easier installation and maintenance, including complete exposure of the breaker by removing only the front cover—standard with I-T-E on low-voltage breakers.

The units—rated at 600 volt in 225-, 600-, and 1600-ampere frame sizes—are for service-entrance and single-circuit requirements in commercial buildings, industrial plants and power stations.

The new models—incorporating the recommendations of an extensive survey of maintenance and installation men—offer four major advances in individually enclosed circuit breakers.

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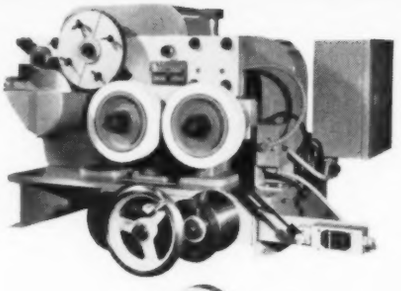

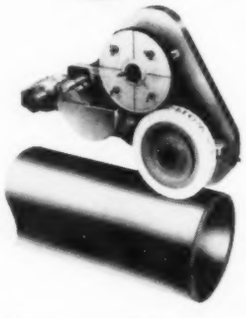

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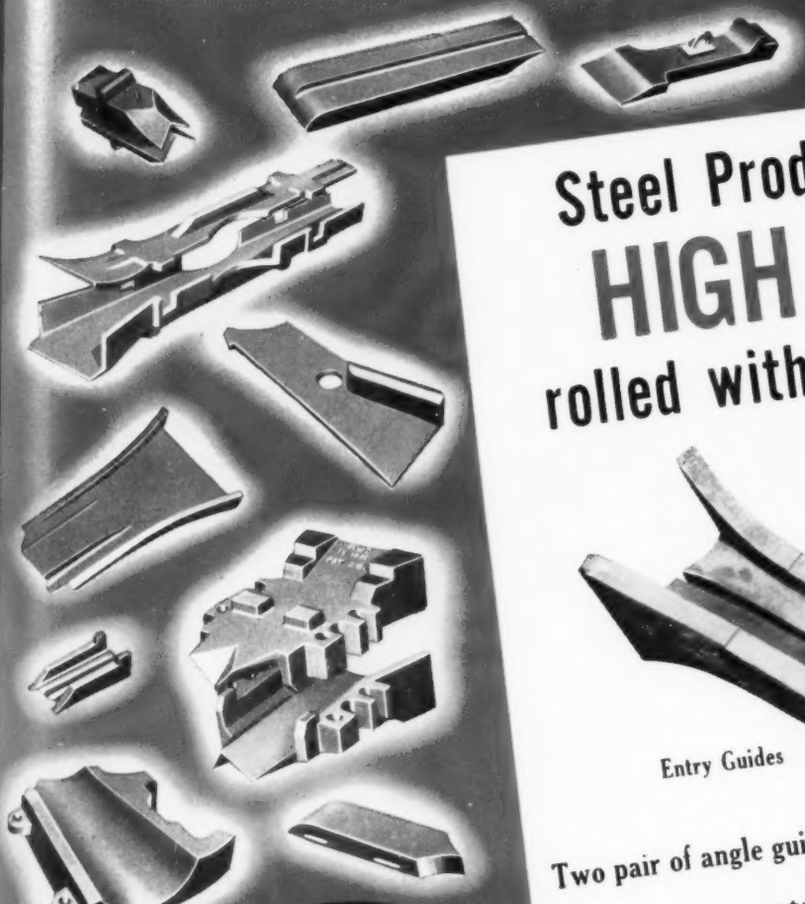
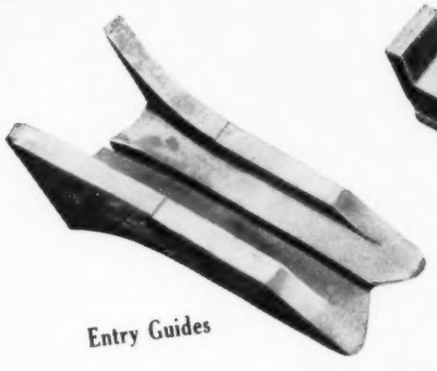
TRANTINYL GUIDES
THE STEEL INDUSTRY



Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES



Entry Guides

Delivery Guides

Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.

12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

Guides for Rolling Mills • Tube Mills
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100-ton Bedford gantry crane with 15-ton auxiliary hoist, 130′ span and 30′ lift, owned by a large eastern fabricating plant.

100 Ton Bedford Gantry Crane

This big Bedford gantry crane is equipped with mill type 600 series motors—magnetic dynamic lowering on both main and auxiliary hoists—magnetic reversing plugging control on trolley and bridge motions—Tool Steel Process gears and pinions—eight 36″ straight tread carburized steel bridge wheels. Bridge girders are riveted construction, and each bare girder weighs 92 tons.

All control panels are of the open type, mounted in a walk-in steel control house. Bridge drive is through individual worm drives mounted on each of two bottom bogie trucks controlled by a duplex panel.

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Backed by more than half a century of *specialized* crane engineering and fabricating experience . . . Bedford Cranes have won fame the world over for advanced design and for safe, smooth dependable performance.

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contacts can be checked through opening in the side of the enclosure.
2. Breaker can be withdrawn to disconnect position without removing front cover.
3. Unprecedented access for making cable connections.
4. Any standard lugs can be used in making cable connections.

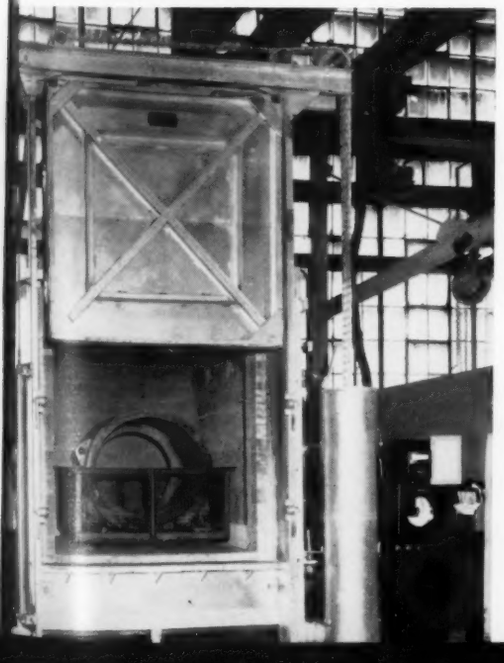
Visual inspection of the breaker contacts is provided as a safety precaution. The visual check is made possible by openings with transparent covers on the sides of the enclosure which allow the operator to see the disconnect contacts.

The breaker can be withdrawn by means of a crank-operated mechanism without removing the front cover of the enclosure—yet the break is visible.

The completely enclosed breaker can be padlocked in the "visible break" position, assuring that the circuit cannot be accidentally closed. In addition, because the front cover seldom, if ever, need be removed,

HEAT TREAT FURNACE

Largest furnace ever shipped as a packaged unit by Surface Combustion Corp., adds flexibility to the heat-treating operations of a leading manufacturer of electric motors and controls. This large oven furnace eliminates production problems by performing many different heat-treat cycles and accommodating a variety of part sizes to be heat-treated. Operating range of the furnace is 600-2000 F. Large weldments, forgings, castings and shafts 63 in. long, handled in an upright position, are easily processed in this furnace, which heat-treats 7500-lb work loads.



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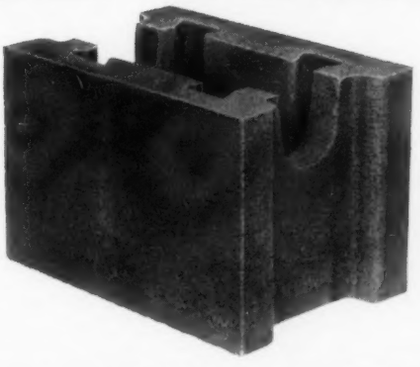
FURNACE BLOK*



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the breaker is protected from dust and dirt and other foreign particles.

The enclosures are designed to accommodate cables one size larger than standards usually require for each breaker size and still provide ample working room. In addition, all obstructions can easily be removed when making difficult cable connections.

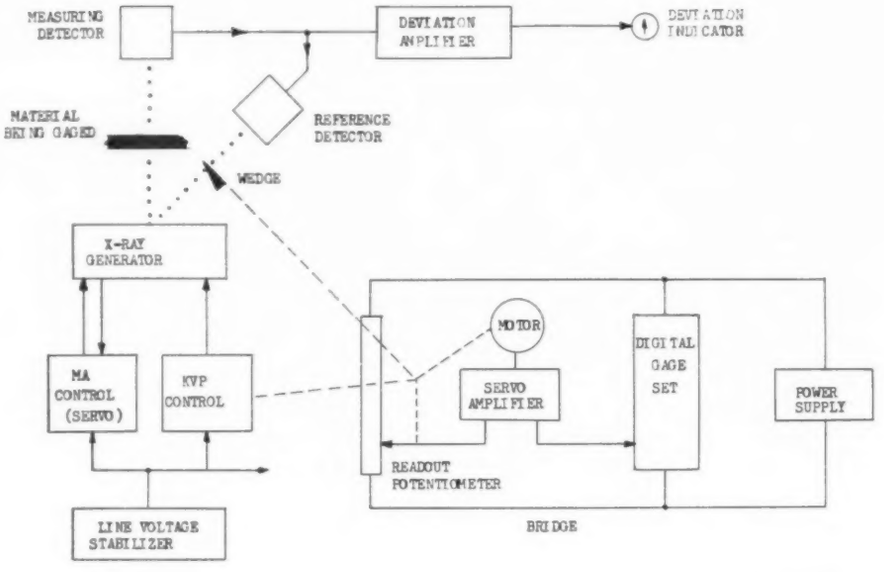
A unique universal lug adapter mounted on the stationary contacts permits cable connection with any standard lug—thus ending installation delays caused by lack of proper connectors.

X-RAY GAGE

△ An x-ray thickness gage, designed for hot and cold strip rolling mills, will soon be offered by the x-ray Department of General Electric Co. The unit, which was recently exhibited at the Iron and Steel Exposition, is called the "Raymike 600."

High reliability, simplicity of service and ease of operation have been attained in the design of the gage. "Raymike 600" is a coined name signifying "x-ray micrometer" capable of gaging steel up to 600 mils thick.

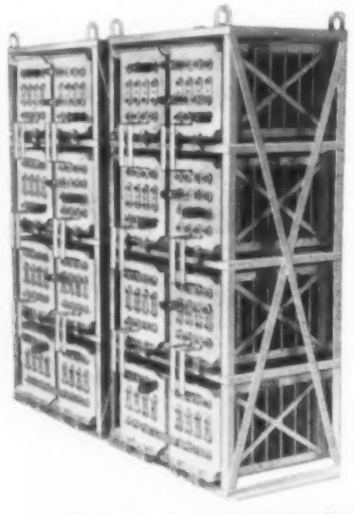
RAYMIKE 600 BLOCK DIAGRAM



The unit features transistorized plug-in electronic panels which accounts for greater reliability and ease of service. Ultra accuracy and maximum stability are assured by incorporation of a balanced or dual beam x-ray system utilizing a time-tested x-ray tube.

Quick error-free thickness selection is accomplished by means of a digital setting feature. The exceptional accuracy of this gage allows continuous tolerance control of strip to better than 1 per cent of thickness being measured.

The gage will be marketed by the Apparatus Sales Division of the General Electric Co.



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Book Review

Joseph Marin, Professor and Head, Department of Engineering Mechanics, the Pennsylvania State University, University Park, Pa., has announced that the proceedings are now available for two short courses conducted during the past summer dealing with materials engineering design for high temperatures and mechanical properties of materials.

"**Automatic Process Control,**" by Donald P. Eckman has recently been published by John Wiley & Sons, Inc., New York, N. Y. The book contains 368 pages, 6 x 9 in., is cloth bound, and sells for $9.00. Important principles of automatic control, with emphasis on block diagrams and frequency techniques in process control, are discussed in this book, beginning with process analysis and progressing on into the generalized behavior of closed-loop

(*Please turn to page 194*)

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Book Reviews

(Continued from page 192)

systems. System problems are given considerable study. Analyses techniques are used to the fullest extent, with enough detail being carefully presented to allow close inspection of some of the more difficult problems in automatic process control. Also incorporated are numerous problems and answers with nine detailed experiments including the analog computer. Such special topics as new electronic controllers, control elements and actuators, nonlinear elements often encountered in process control, Nyquist and Bode diagrams, fluid and thermal process control, computer optimizing control, and direct comparison of control actions are featured.

"Stahleisen-Worterbuch" (Iron and Steel Dictionary) German-English; English-German, has been recently published by Verlag Stahleisen M. B. H. Dusseldorf, Breite Strasse 27, Postschleissfach 2590. Distributing agent for the U. S. A., H. K. Lewis & Co., Ltd., 136 Gower Street, London, W. C. 1. The book contains 272 pages (pocket size), approximately 5½ x 4 in., bound in imitation leather, and sells for £ 1.1 plus 1s.4d postage. Over 7000 technical terms relating to the iron and steel industry, and many technical terms which are especially difficult to translate, are included in the dictionary. Several more important terms of a business nature are also included. Many conversion tables—lengths, surfaces, volumes, weights, heat quantities, pressures, weight per unit volume, energy measurements, power, heat quantity per unit of surface, volume or weight, heat conduction, temperatures, various measures, viscosity of liquids, abbreviations facilitate the rapid conversion of British and American units into German units and vice versa.

"Separation and Purification of Materials," by Rolt Hammond, has been published recently by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 327 pages, 6 x 9 in., is cloth bound, and sells for $10.00. This book covers solid-solid, solid-liquid, solid-gas, liquid-liquid, liquid-gas and gas-gas systems and a final chapter on separation and purification in nuclear engineering. Considering the multiplicity of plant and equipment available, the main types have been described so that a suitable choice may be made for specific purposes. Particular attention is given to atmospheric pollution both by sulphur compounds and by dust.

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Look at these features—many of them exclusive with the patented POOLE:

Adjusts itself to all conditions, leaving its members free to float without strain to parts.

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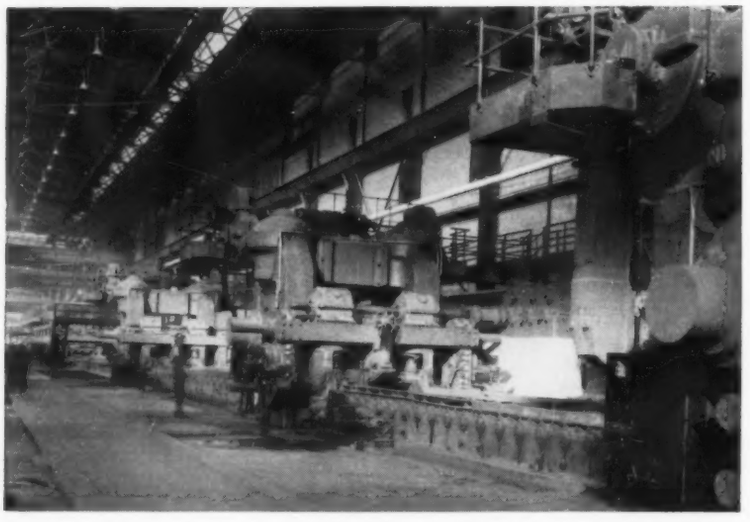
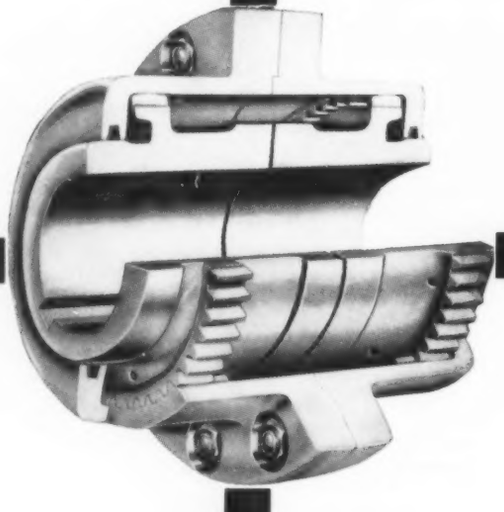


Steel mill drives equipped with POOLE FLEXIBLE COUPLINGS.



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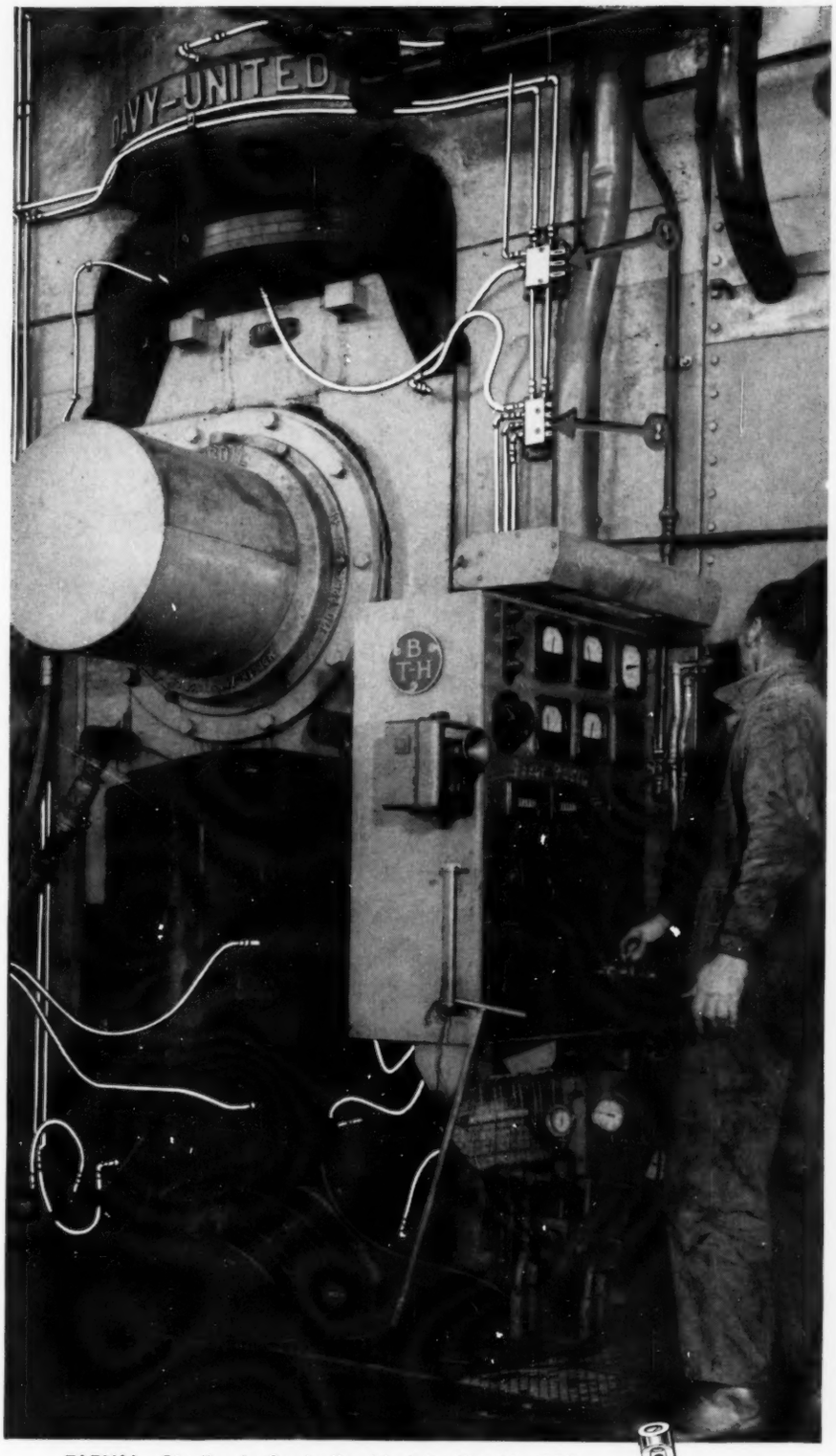
Farval
lubrication systems serve 600 points on Australian steel mill



Modern Farval lubrication systems help maintain high-production rates on this 1200 fpm cold reduction mill in the Port Kembla, Australia, facilities of Lysaghts Works, Ltd. They dependably provide around-the-clock lubrication at regular intervals to 260 bearings on this recently installed mill.

Automatic systems serve bearing housing slides and screw-downs every two hours and work roll bearings every half-hour. Manual systems, operated at the start of each shift, require only five minutes' time. Additionally, 340 other lubrication points on metalworking machinery in this plant are served by Farval systems.

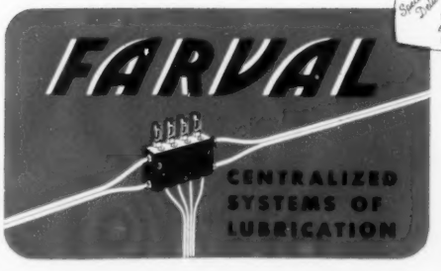
Whatever the country, wherever steel is being made or worked, you're sure to find Farval lubrication systems protecting bearing life of metalworking machines.

To see how correct lubrication can cut labor costs and reduce downtime in your own operations, ask for revised Bulletin 26-S. Write today to The Farval Corporation, *3278* East 80th Street, Cleveland 4, Ohio.

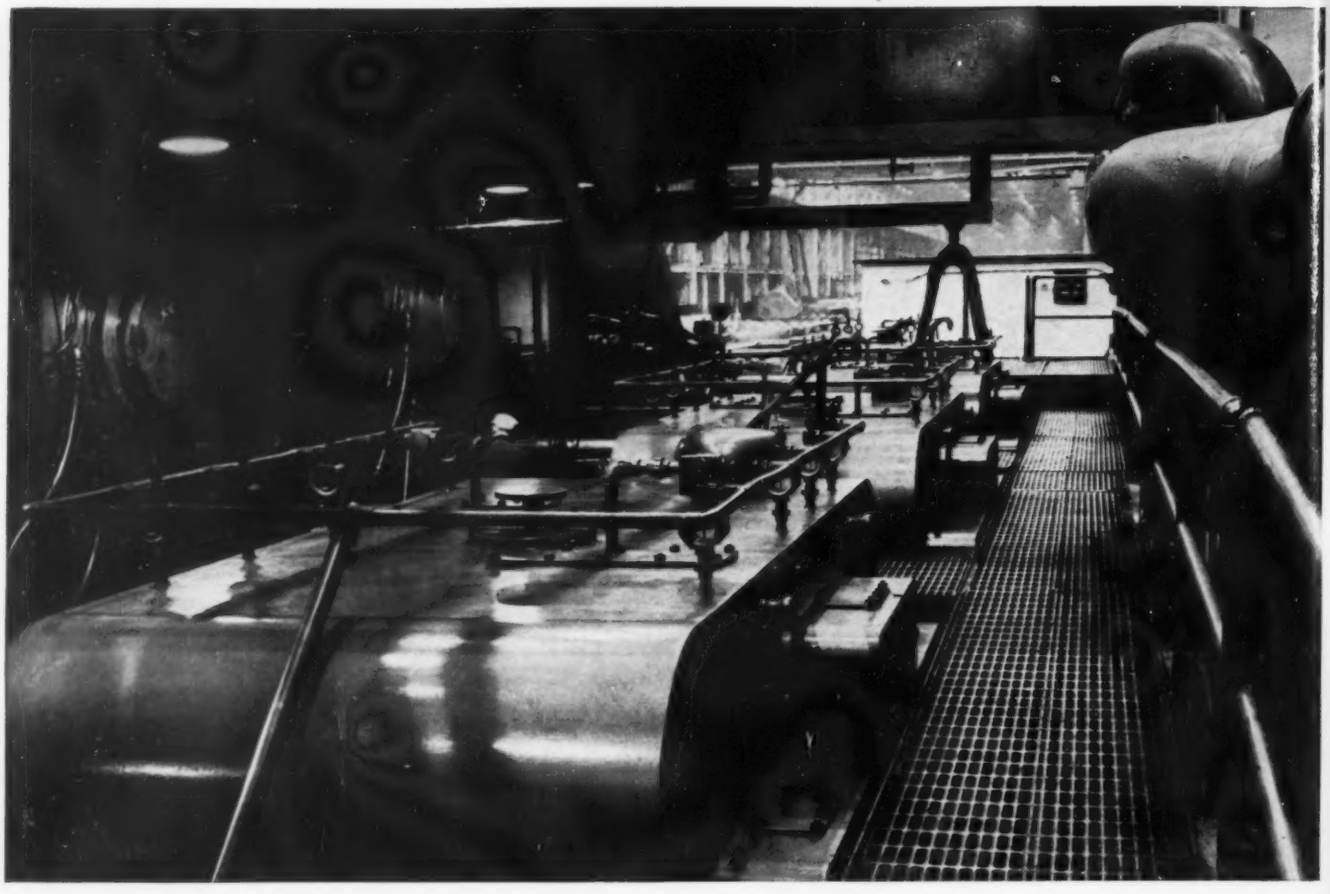
KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval —familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.

FARVAL—Studies in Centralized Lubrication No. 223



Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



Steel strip whizzes through this mill at 80 miles per hour...

It's a high-speed, cold reduction five stand tandem mill at Weirton Steel Co., Division of National Steel Corp. It rolls strip in widths to 48" by .008" thick. Gear drives are fully protected with *Texaco Meropa Lubricants*.

Today's steel mill equipment operates faster, carries heavier loads. That's why the long-lasting extreme pressure properties of *Texaco Meropa Lubricants* are so important in protecting gears and bearings from wear and damage. They cushion metal surfaces against shock or prolonged heavy loads.

Texaco Meropa Lubricants also contain exclusive polar additives that keep them where they're needed, even under conditions of severe heat, pressure or moisture. Moreover they resist thickening, do not foam, won't separate, and are non-corrosive to gear and bearing metals. All good reasons why *Texaco Meropa Lubricants* help gear your mill to higher efficiency.

Let a Texaco Lubrication Engineer give you further details. Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write:

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